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MAY 1956

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Let us do our duty in our shop or our kitchen, the market, the street, the office, the school, the home, just as faithfully as if we stood in the front ranks of some great battle and knew that victory for mankind depended upon our bravery, strength and skill. When we do that the humblest of us will be serving in that great army which achieves the welfare of the world.—THEODORE PARKER.

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SCHOOL SCIENCE AND MATHEMATICS

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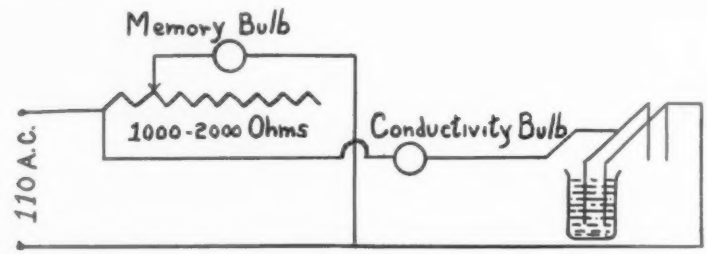
DEMONSTRATION DEVICE FOR THE CONDUCTIVITY OF ELECTROLYTES

F. P. Cassaretto
Loyola University, Chicago, Illinois

For several years we have used the following equipment to introduce our freshman students to the concept of electrolytes and ionization. The design of the equipment, although not original, is simple and easily prepared from inexpensive materials. The effectiveness of this equipment in demonstrating electrolytes will amply repay the instructor for the little time and effort spent in its construction.

The equipment is easily prepared from a few feet of electrical cord, several feet of number 18 copper wire to serve as electrodes, two 40 watt light bulbs and sockets, and a variable slide resistance of some 1000 ohms. One light bulb is connected in series with the resistance and is independent of the copper electrode circuit as shown in the wiring diagram below. The other light bulb is, of course, connected in series with the copper electrodes used for the conductance cells. The electrodes are mounted on the sides of a block of wood 2″×2″×6″ which carries a small dowel rod inserted in the top as a handle. The block and connections are covered with insulating tape leaving only the four extending electrode prongs exposed. The two sets of electrodes connected in parallel permit the measurement of the current carrying capacity of two electrolytes before and after mixing and also do away with the factor of varying electrode area on the total conductance of a solution. The bulb independent of the electrolyte in the cell may be adjusted by varying the resistance as sort of a "memory" light so comparisons are more effectively made before and after dilution or reaction. The device has been found to be most effective in showing the increased conduction of acetic acid with

dilution by placing one set of the electrodes in a normal solution of acetic acid and the other set of electrodes in a beaker of distilled water that will be subsequently used to dilute the acid. The "memory bulb" is then adjusted to comparable brightness by means of the variable resistance and the distilled water added to the acetic acid. The conductivity bulb increases in brightness as dilution proceeds. Since the exposed electrode area is constant before and after dilution the increased intensity of the light bulb may be more directly attributed to an increase in ionization of the weak acid. The increased conduction as a result of salt formation may be shown spectacularly in a similar manner by mixing equivalent quantities of weak acids and weak bases.



Electrolytes and nonelectrolytes are easily identified in the usual way using only one set of electrodes. Care should be exercised in a series of determinations to rinse the electrodes thoroughly after each experiment and the demonstrator should remember that the conductance electrodes are "hot" once the equipment is plugged into the 110 volt A.C. circuit. One "imaginary" shock adds to the showmanship of the demonstration.

NEW SCIENCE SCHOLARSHIPS

A series of special scholarships aimed at increasing the nation's supply of adequately trained secondary school science teachers has been established at the Massachusetts Institute of Technology, it was announced last night by Dean T. P. Pitre, Director of Student Aid at M.I.T.

Beginning next fall the Institute will award a number of scholarships in amounts ranging up to full tuition to junior students who have elected the Institute's professional program in science teaching. The scholarships will be renewable.

In announcing the new scholarships for prospective teachers, Dean Pitrie emphasized that the current critical demand for scientifically trained personnel has spotlighted a national deficiency, at the secondary school level, of properly qualified people in science teaching.

It is also common knowledge, he said, that the number of people entering the teaching profession has not kept pace with present and projected demands.

PHYSICS AND PHYSICISTS AT GENERAL MOTORS RESEARCH

D. L. Fry
Senior Physicist, General Motors Corporation, Detroit 2, Mich.

Much physics is done by scientists other than physicists, and physicists work in many fields other than physics. Like the uncertainty principle of Heisenberg which states that one cannot both measure the velocity and the location of a particle exactly at the same time, so we find that we cannot define the work of a physicist and the field of physics exactly at the same time. This indefiniteness is good, and it is fun, because it allows the expression of personality to shine through into even the cold world of facts. Physicists, like teachers, are not cold, reserved intensely critical men, overriding the moral, social, and business activities of the world with aloftness and sneers, but warm human beings living in the same world and with the same problems as every one else. Physics, likewise, is not an ivory tower profession demanding machine-like precision and personality, but an exciting field with breath-taking orderliness and sufficient confusion to challenge the creativity of ordinary human beings. It is the purpose of this talk to convince you that industrial physics is an enjoyable and useful occupation, and that it is worthwhile to interest high school students in this field. Also, I hope to indicate the type of training which would best satisfy the needs of industry.

I also have two personal reasons why I wanted to give this talk. The first is that those of us who work in industrial laboratories are much concerned with educational problems. We have the continuous necessity of self-education to keep up with our field, and of the education of others with regard to the applications of our own ideas and those of others contributing to our field. The second reason that I wanted to give this talk is that I am a father of three boys, the eldest of which has just entered the seventh grade. You and the ideas you exchange here will probably have a strong influence on my children. I would like to contribute as much as I can to this exchange of ideas and information. To do this I will discuss some of the things we do at General Motors Research which involve either physicists or physics.

Physicists are expected to contribute to General Motors in four ways:

First, we consult on problems involving physics. In this connection we essentially teach college sophomore physics to engineers, chemists,

Presented at the Physics Section of the Central Association of Science and Mathematics Teachers at Detroit, Nov. 25, 1955.

metallurgists, production men, accountants, and even to other physicists. It is surprising how quickly some of us in industry can lose our grasp on the fundamentals of physics in those branches which are not part of our specific specialty. To keep specialists in every field our Research Staff contains men working on every type of material which goes into a car even though General Motors may not produce the material. For instance, we have a Fuels and Lubricants Department which studies petroleum products, with an eye to improving them. Only in this way are we able to keep our suppliers giving us the best and keep ourselves using the best the suppliers can give.

The second expected contribution of the physicist is that he carries out basic research into the nature of materials, processes, and products with which General Motors is interested. For example, we have worked on such problems as the nature of combustion in the internal combustion engine, the nature of friction between sliding surfaces, the physical and chemical processes which accompany the failure of the lacquer film on our automobiles, and how we measure the amount of hydrogen in metals. This research is basic in the sense that our primary purpose is to obtain information. It is industrial research in the sense that it is directed along general lines which are of interest to the Corporation.

The third way in which a physicist is expected to contribute is to keep the Corporation informed regarding new developments in science which may not be directly associated with immediate interests but may eventually affect them. A pertinent example in our own automotive industry is the development of nuclear power. While this does not concern our production men, it is imperative that physicists and other scientists keep the Corporation informed to the best of our ability with regard to such developments.

And fourth, the physicist has the job of introducing new instruments, new techniques, new methods, and new points of view emerging from his own and other scientific laboratories.

These general conceptions will be more clear if I describe the activities of specific men and tell you some of the specific things we have done. I will present brief biographies of three physicists, and then describe six types of work done in physics.

Back in 1928 or 29 we had a Ph.D. physicist start work at our laboratory. Some of his early work was done in x-ray radiography and Raman spectroscopy. However, he was soon teamed up with a man who had a Ph.D. in Physical Chemistry and was working on the nature of combustion in an engine. They were specifically concerned with what caused knock and how to prevent it. One of the ways they attacked this problem was to put a quartz head on a single cylinder engine and take high speed motion pictures of what happens in an

engine during combustion. The first slide (Figure 1) shows a series of their pictures. This series of pictures is taken during a part of one cycle. It is a picture of normal combusition.

FIG. 1. Flame front progression during normal combustion.

The spark has ignited the air fuel mixture at the left edge of the combusion chamber. The flame front has progressed most of the way

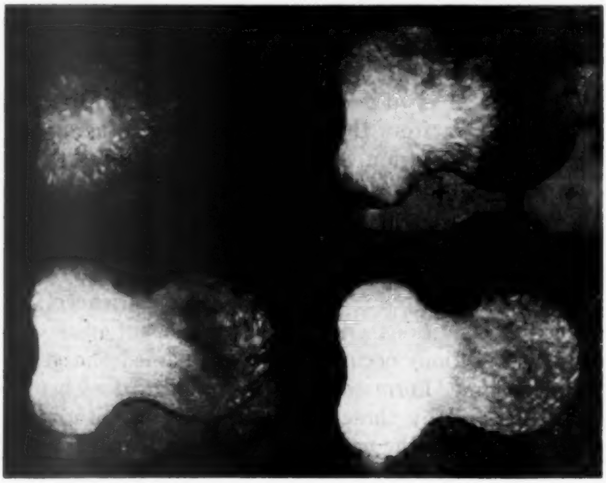


FIG. 2. Preignition during knocking combustion.

across the combusion chamber as shown in upper left-hand picture. The continuous progression of the flame front is shown in the four pictures. Figure 2 shows what happens during knocking combustion. In the upper right hand corner the picture shows that an additional flame front has started at the right hand edge of the combustion chamber. This double flame front consumes the fuel faster; thus causing unusually high temperatures and pressures. Figure 3 shows another series of pictures illustrating knocking combustion.

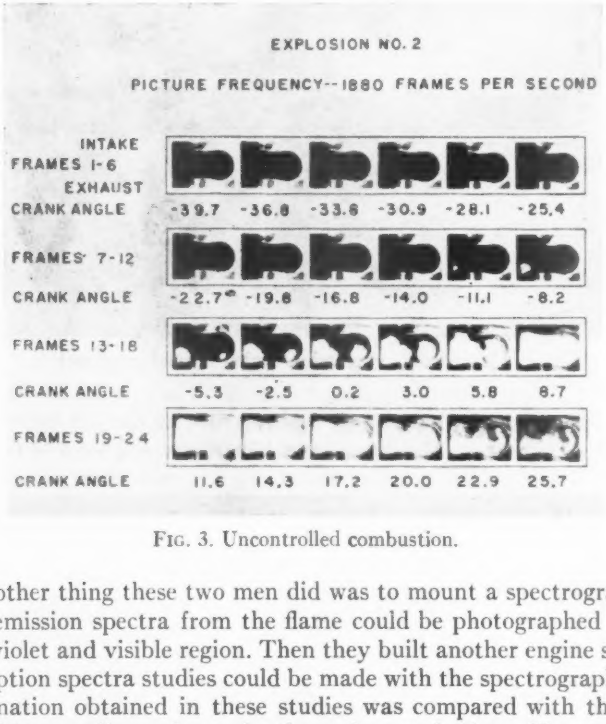


FIG. 3. Uncontrolled combustion.

Another thing these two men did was to mount a spectrograph so that emission spectra from the flame could be photographed in the ultraviolet and visible region. Then they built another engine so that absorption spectra studies could be made with the spectrograph. The information obtained in these studies was compared with that obtained from ordinary flames by themselves and others. The results of these investigations showed that knocking was caused by the increased rate of burning over that normally experienced, and that under knocking conditions chemical reactions not observed under non-knocking conditions occur in the noninflamed charge ahead of the advancing flame. Formaldehyde was identified as being one of the products formed by these preflame reactions. Studies are still taking place today into the nature of these reactions.

After this work this physicist was promoted to the position of Assistant Department Head of the Physics-Instrumentation Depart-

ment where he is daily concerned with problems of physics, chemistry, electrical and mechanical engineering.

Several years ago we hired a Physicist with a Master's degree from the University of Michigan. He came to us after having spent several years with an instrument company and two years at an observatory. His first work assignment was to help the men in electron microscopy determine the shrinkage in a plastic film as it dries. To do this he cast a plastic film on an optical grating, stripped it off, and measured the spacing after the film had dried. He then turned his attention to infrared spectroscopy and has been working on the application of infrared absorption techniques to the study of hydrocarbons and the

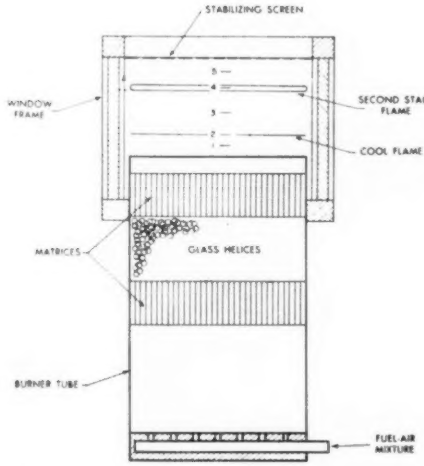


FIG. 4. Burner used in precombustion oxidation studies.

products of combustion of hydrogen. His most recent contribution was to study the precombustion oxidation of fuels in a burner. This is essentially a continuation of the earlier combustion work which I discussed. Figure 4 shows a diagram of the burner which is used. The air and fuel is mixed at the bottom. If a hot wire is placed near the top a white glow will occur at positions 2 and 4. The current through the wire can be turned off and the wire will cool off but the white glow will continue. This white glow is actually due to the fluorescence of formaldehyde and occurs at temperatures below the flaming temperature of the fuel-air mixture. Figure 5 shows a picture of this cool flame. In this study this physicist showed that the same reactions take place in a flame as in an engine and that thermal equilibrium exists under conditions of cool flame combustion. Hence infrared

methods can be used to find the instantaneous temperature in an engine.

In 1952 we hired a man who had a Bachelor's degree with a physics major. He has been taking night school work ever since in order to get a Master's degree. For three months this man assisted in the calculations of residual stress in metal specimens. This is done somewhat as follows: We'll use a straight bar in the example. A small amount of metal is gently ground off one edge. The curvature of the bar is measured and the residual stress in the amount of material ground off is computed. More material is ground off and again the residual stress is computed. However, this new figure has to be corrected for the fact that the original bar was larger and that the removal of the first layer of residual stress changed the stress in the second layer. The residual stress is computed throughout the entire piece in this step-by-step procedure. A good deal of this work is now done with

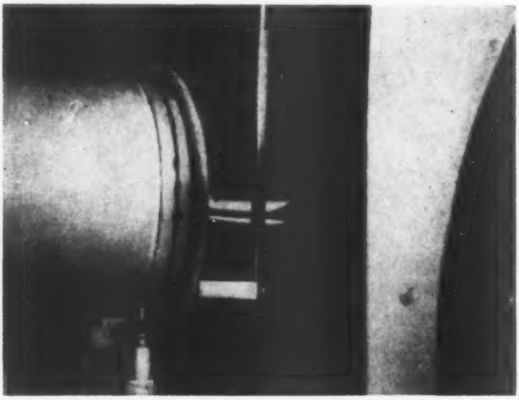


FIG. 5. Photograph of cool flame in burner.

an IBM computer. But for each new shaped piece hand calculations have to be made to check the computer.

For the next three months this physicist obtained visible and ultraviolet light absorption spectra of oils. For the last several years this man has worked in the field of emission spectroscopy. He helped another physicist develop a method of analyzing a nickel base alloy for its various metallic constituents, he has worked on a general procedure of analyzing powders for any metal, he has kept an up-to-date bibliography of spectrochemical literature, and recently he has been working on the problem of quantitatively analyzing a mixture of gases for specific compounds.

These brief biographies illustrate a portion of my opening remarks

by showing how physicists in industry work in fields other than physics. Specifically these three men have spent the major portion of their time in physics but in addition have worked in the fields of physical and organic chemistry, mathematics, and mechanical engineering. Now let us consider some of the physics we do and the background of the men who do it.

For example, let us first take spectrochemical analysis. As it is used it is really in the field of analytical chemistry. However, the basic principles on which it stands are physics. Men have been working in this field at General Motors Research since 1922. Partially through

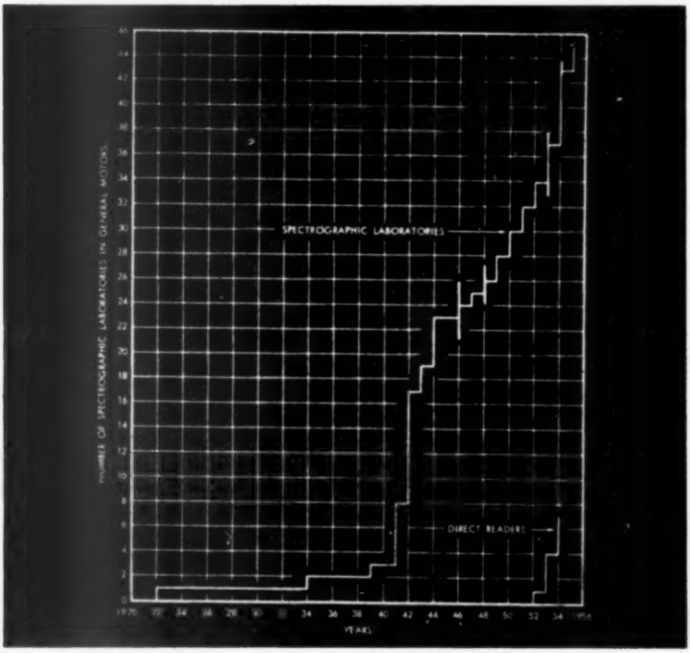


FIG. 6. Increased use of spectrographic analysis in General Motors.

their efforts the entire corporation has taken up with the instrument and the procedures as shown by the curves in Figure 6. The upper curve is a plot of the number of spectrographic laboratories versus years. For a good number of years the Research Staff had the only instrument in the corporation. In 1934 AC Spark Plug Division acquired an instrument. We had a sudden growth during the war and then a continual rise ever since. Today we have 45 spectrographic laboratories in the Corporation. This growth has kept our men at

Research busy educating people in the use of the equipment and methods. In recent years a new kind of automatic spectrograph called a direct reader has been used. The lower curve in Figure 6 shows how the number of these installations are increasing.

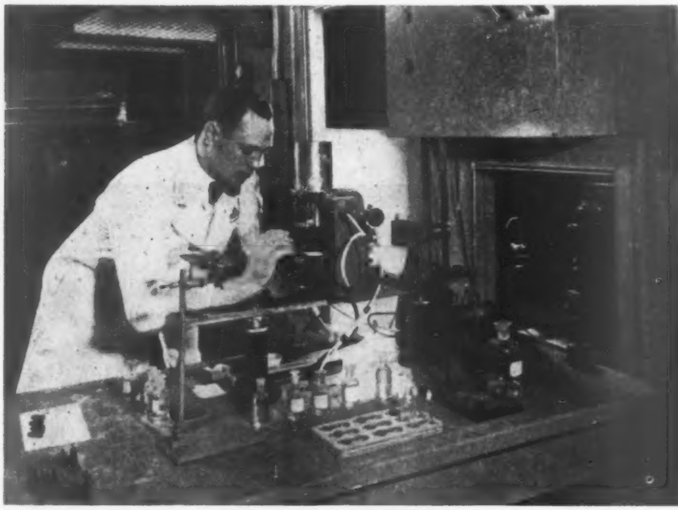


FIG. 7. Analyzing blood for lead.

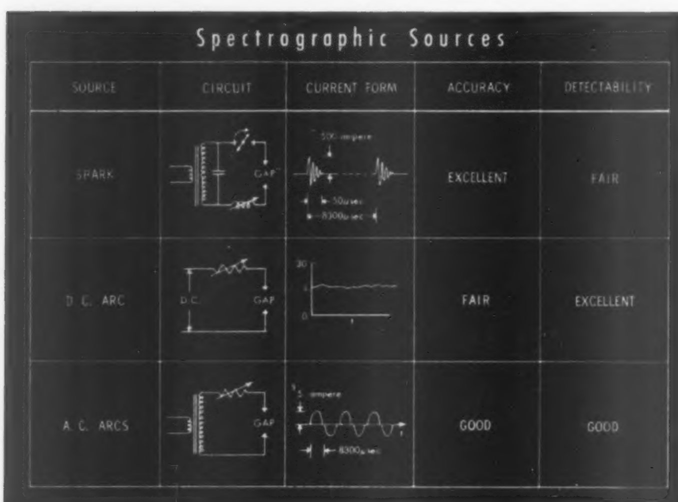


FIG. 8. Electrical circuits used in emission spectroscopy to excite samples.

Figure 7 shows a man with a Master's degree in Physics working on the establishment of a method of analyzing blood for lead. Last year a separate spectrographic laboratory was set up to make these analyses routinely.

Figure 8 shows circuit diagrams of some of the electrical circuits used in spark and arc sources for causing the samples to emit light. Our men are continually examining the output of these sources and trying to relate the circuit parameters with the spectra one obtains. The picture shows the current form and lists its relative value in analytical work. It is our present thinking that if we could find a way

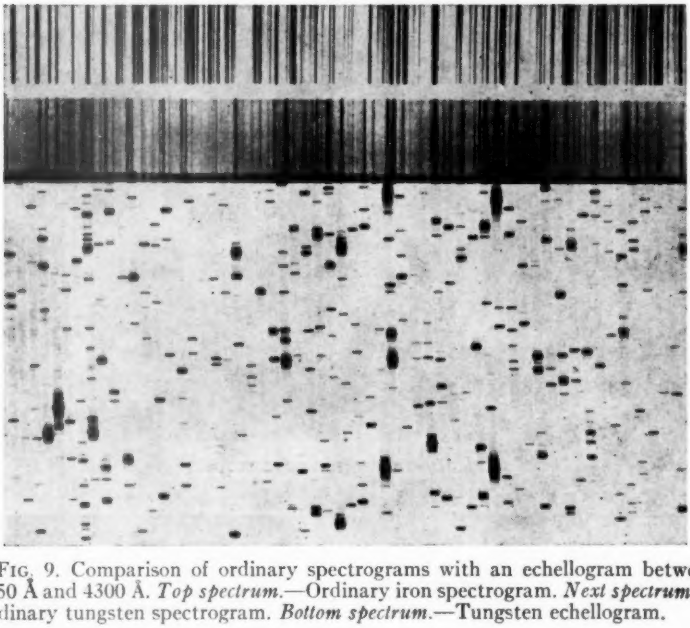


FIG. 9. Comparison of ordinary spectrograms with an echellogram between 3750 Å and 4300 Å. *Top spectrum.*—Ordinary iron spectrogram. *Next spectrum.*—Ordinary tungsten spectrogram. *Bottom spectrum.*—Tungsten echellogram.

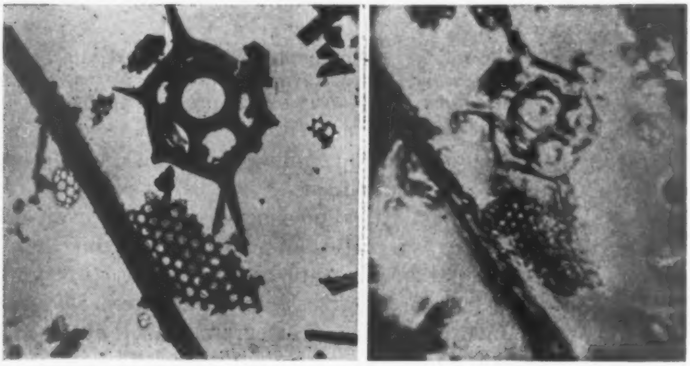
of completely describing the current form we would be able to predict the spectrum which would be obtained.

Figure 9 shows another activity of men in this group, the evaluation of equipment. At the top is a picture of a spectrum of pure iron as obtained on a commercial spectrograph. Below it is a spectrum of tungsten. The wavelength of the lines shown vary from 3750 Å to 4300 Å. Below is a Littrow-Echelle spectrogram. This is obtained by crossing the dispersion of a prism with the dispersion of an echelle. Each of the strips in the lower spectrum is a small section of the tungsten spectrum blown-up. This increased dispersion gives certain

advantages to the practicing spectrographer. We are trying to accurately define the value and limitations of these advantages.

Another field which we are examining at present is the field of elec-

FIG. 10. An electron microscope.



Electron Microscope Optical Microscope

FIG. 11. Two pictures of diatomaceous earth at 2000× magnification.

tron microscopy. Figure 10 shows a picture of an electron microscope which we purchased in 1946. In order that the microscope would be accepted by the metallurgists and the engineers it was necessary to gradually progress from the known to the unknown. So the first phase of our program was to take many pictures of the same specimens with optical and electron microscopes, using comparable magnifications, in order to demonstrate that under these conditions one sees the same things with both instruments. Then the magnification was increased with both instruments to show the higher resolution

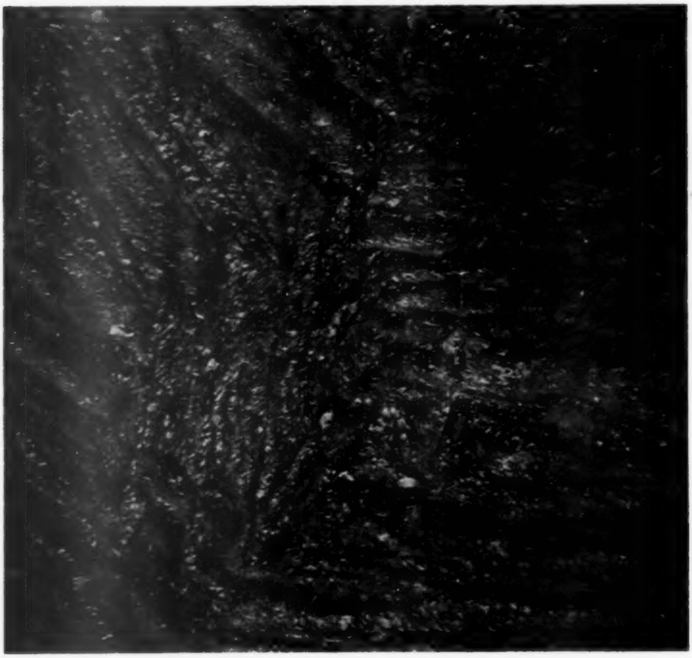


FIG. 12. Lower banite structure in steel.

which can be achieved with the electron microscope as compared to the optical microscope.

Figure 11 shows two pictures of the same field of a sample of diatomaceous earth. The magnification on the original photographs was about 2000×. The picture on the right was taken with the optical microscope and the other with the electron microscope. The great advantage of the electron microscope is of course its resolving power. Pictures of this type are very important in selling to our colleagues the higher resolution of the electron microscope.

The real usefulness of the electron microscope is illustrated in Figure 12. This shows an electron micrograph of a metallurgical structure known as lower bainite. The marker is one micron long. The little white flecks in the picture are carbide platelets deposited in a ferrite matrix. These carbides could never be seen with an optical microscope although it was suspected that they were present. I would like you to notice that these carbides are aligned with respect to the larger needles. This alignment was not even suspected until seen here. Information of this type will help to fill some of the gaps of our understanding of the metallurgy of steel.

FIG. 13. X-ray diffraction equipment.

Figure 13 introduces another phase of our work in physics—X-ray diffraction. The man in the picture came to us as a chemical engineer. He has since obtained a Master's degree in Physics. X-ray diffraction is a relatively old art and yet it has found only very limited application in General Motors. There are only two active laboratories outside of the one at Research. At present we have two active projects in this field. The first is the development of a better method to quantitatively measure the amount of retained austenite in steel. The second is the measurement of internal stress in various metallic parts.

Figure 14 shows an instrument which we are building. We call it a spectroheliometer. The information obtained with it will be used in connection with our study of the fundamental process of the weathering of automotive finishes and with our work on obtaining solar energy. We have suspected that only certain wavelengths of the sun's light causes deterioration of paint. Therefore, in our testing of paint panels it is important we know the spectral distribution of the sun's energy. Also one method of collecting solar energy is to find a material

FIG. 14. A spectroheliometer.

which has a high absorptivity in the region of the sun's radiation but a low emission in the heat waves region. Because of these two facts these two physicists whom you see in this picture developed this instrument which consists of a spectrograph with six radiation thermopiles distributed along its focal plane and with an integrating system to measure the sun's energy in each of six wavelength bands. This is mounted so as to follow the sun across the sky.

Another instrument which we have made was developed by an electrical engineer. It uses the physical phenomena which we call the thermoelectric effect. The purpose of this instrument is to sort mixed stock in a production plant. Occasionally it happens that two different steel stock piles become mixed. This mixed steel is then used to manufacture some part. But one of the steels is not satisfactory for this purpose. The plant then requires a very rapid and inexpensive method of separating the steel. We use the difference in thermoelectric emf between the two steels to sort them. In principle the instrument consists of two metal probes, one of which is surrounded by a heater and the other of which is kept at room temperature. They are connected through an electronic amplifier to a meter. The two probes are brought into contact with the piece to be tested. The reading on the

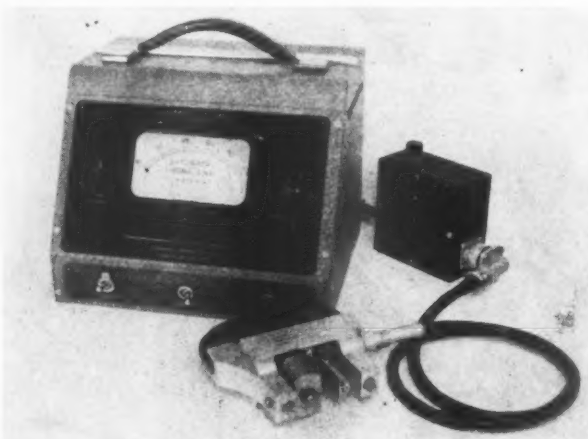


FIG. 15. A thermoelectric comparator.

meter is, of course, proportional to the thermoelectric emf between the probes and the piece under test. Fortunately for this method, this thermal emf is very sensitive to small changes in composition. Even a change in carbon content of the steel will change the thermal emf. And so after some preliminary experiments with the two steels to obtain the meter reading which may be expected from each, the operator merely presses the two probes of his instrument against one after another of the pieces of steel, separating them into two piles depending upon the meter reading. Figure 15 shows a picture of this Thermoelectric Comparator.

The last work in physics which I want to describe today is done by an Electrical Engineer. This man has measured directly the mass to

charge ratio of the charge carrier of electricity in copper, aluminum, and cadmium. To do this it is necessary to have a magnetic and vibration free space. To get freedom from vibration we have built a building out in the country. To get a magnetic free space we have built the Helmholtz coils shown in Figure 16. These are three mutually perpendicular coils. There are actually two sets of coils shown in the figure; a smaller set inside a larger one. Any changes in the earth's magnetic field are detected and the current in these coils is varied to exactly counteract the change in the earth field. Inside of

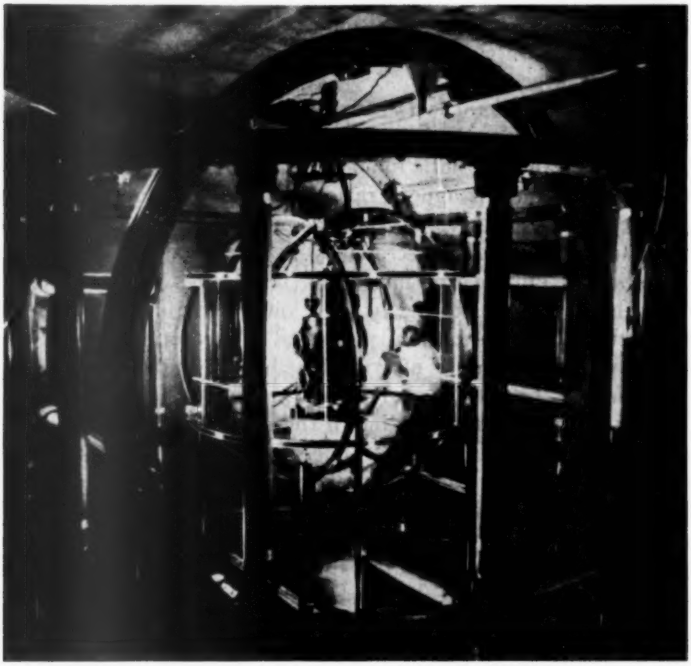


FIG. 16. Magnetic free space surrounded by Helmholtz coils.

this magnetic free space an apparatus like a galvanometer is placed. It is called a torsional pendulum. The rotation of the pendulum is measured with a mirror-to-scale distance of 52 feet. To measure the mass-charge ratio of the current carrier a coil is wound from the wire it is desired to use. The coil is suspended in the magnetic free space. Current is turned on. The coil will rotate slightly because of the inertia of the charge carrier. When the coil goes back through zero position the direction of the current is reversed giving the coil a kick in the opposite direction. Each kick increases the deflection at 52 feet

about .05 mm. This is continued for about 60 swings, the period of the pendulum being about 30 seconds. By this time the total deflection is of the order of 3 mm. This process is repeated several times and from plots of this deflection data the inertia of the charge can be computed. The value of m/e is obtained by setting the ratio of the angular momentum to magnetic moment equal to $2\, m/e$. The values of m/e obtained agreed with the values obtained by other less direct methods.

There is a phenomenon in physics called the Hall effect which according to past theories would indicate that in cadmium the electrical current carrier was a positively charged particle. With this equipment it was shown that copper, aluminum and cadmium all used a negatively charged carrier.

Further experimental facts have been determined with this equipment. By inserting a metal rod inside the coil the ratio of the angular momentum to the magnetic moment of the rod could be determined. This is called the gyromagnetic ratio or the magneto mechanical ratio. Measurements made several years ago on iron, nickel and cobalt and their alloys indicated a discrepancy between values obtained this way and those obtained by microwave techniques. Recently we have shown that by extrapolating to very low magnetic fields agreement is obtained. This information is of value to theoretical physicists.

I believe these examples of work done by physicists, and work done in the field of physics at our laboratory have illustrated that for industrial purposes men working in these fields should have a broad scientific or technical training. Their nominal training may be in various fields such as engineering, chemistry, metallurgy or physics. The most valuable physics background is general classical physics including mechanics, light, heat, and electricity. At the high school and junior college level I would like to see classes in physics in which the inter-relationship of all physical sciences were stressed so that students would recognize no borderlines to their field. The ideal physics student from the viewpoint of our industry would be one who was interested in all branches of science and who had proficiency in at least one branch of physics. To develop such a person is I hope one of your goals.

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SOME IMPLICATIONS AND PRACTICAL APPLICATIONS OF RECENT RESEARCH IN SCIENCE EDUCATION: NO. 2

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The first of these non-technical reviews of research in science education appeared in the *Journal of Education* for October 1954. That review summarized the findings of research studies that had been undertaken during a number of preceding years. This review, however, deals chiefly with the more recent science education research.

Obviously, it would be a tremendous task to cite individually the more than one hundred investigations contributing to this review or to discuss individually their methods and findings. Hence, as with the last report the findings will be summarized without identifying the sources. Also since the objectives of the teaching of science from the kindergarten through the college are the same, the review will not be categorized into educational levels.

For convenience, the studies have been summarized under the following major headings: (1) The Science Curriculum; (2) The Teaching and Learning of Science; (3) Facilities for Science Instruction; and (4) Scientists and Science Teachers.

THE SCIENCE CURRICULUM

Trends in Science Curriculum

A number of studies have been undertaken whose aims have either directly or indirectly been focussed on trends in science education. Without regard for the educational level with which the studies deal, the same general conclusions seem to emerge. There has been a steady growth of science curricula designed for general education. Yet, this trend has not seemed to interfere with the development of programs for those interested in the more specialized aspects of science. This latter point is adequately supported by the great interest in science education for the gifted and college-bound student.

However, the concern with functional courses for general education has left its mark on college-entrance science. Many reports underscore the need for making college-entrance science more functional by emphasizing current problems of social significance that integrate both the sciences and non-sciences. In general one may conclude that

much still needs to be done in developing curricula at all levels that are based on the psychology of learning rather than on logical and mechanical arrangements of subject matter.

Despite the efforts of workers in science education, to develop better curricula, one trend is disturbing. A number of recent reports show that enrollments in general education science courses have climbed steadily but those in the specialized courses have declined sharply. This latter situation has resulted in a critical shortage of scientists and science teachers. While much study has been devoted to this problem, the causes are still obscure and the solution is far from being reached.

Content of General Education Science

A number of studies have been undertaken for selecting the content of the science courses for general education. These studies have dealt with all educational levels and have investigated the types of courses that seem to be most appropriate, as well as the concepts and problem areas on which they should be based.

At the elementary-school level, many studies have been aimed at the grade placement of science topics and concepts. Generally, they involve an analysis of courses of study for elementary science or seek opinions of teachers as to suitable content and placement. In general they show that courses of study in elementary science are in harmony with what teachers deem suitable. They show also that the courses of study or syllabi from the various areas of the United States are quite similar. Most of the units in these syllabi are "written-down" from the units taught in science courses in high school. Ordinarily the courses of study in science cover the entire elementary-school level, few if any being prepared only for one grade. The similarity in content just described, however, does not apply to the individual grade levels. While the *total* contents of the syllabi are similar, the grade placement of areas of study are quite different. While many efforts have been made to find the "common denominator" of science subject matter for the various grade levels, there is no evidence that they have been successful. Nearly all these investigations did suggest that courses of study should place more emphasis on *how* rather than on *what* to teach.

At the junior-high and senior-high school levels, the general education studies deal with many areas that formerly received little attention, namely, conservation education, earth science, and general physical science. None of these studies seemed to suggest that separate science courses should be developed in the first two areas although in many states conservation education in some form or another is now mandatory with the emphasis on renewable rather

than exhaustible resources. But the rapid growth of the course in general physical science is the major curriculum activity in general education science at the high school level. Most of the studies attempt to ascertain the place of the first two areas in general-education science and to suggest ways for integrating their basic principles with the general education program. In general it may be concluded that further work needs to be done in integrating the above areas with the traditional ones of biology, chemistry and physics in general-education science.

At the college level, many studies have concerned the survey course in biological science. Yet only one published study was found that dealt with the survey course in physical science. Those dealing with biology show that in all but a few of the small private liberal-arts colleges, the biology course for general education has been accepted. In most institutions this course is included in the general-education block, except for students majoring in biology. The content of this course has been studied intensively. The research findings indicate that the traditional systematic arrangement of botanical and zoological topics is inconsistent with the purposes of the course. Many efforts have been devoted to locate suitable problem areas that emphasize life processes, community resources and scientific method. As yet no general agreement as to content has been reached, although there is considerable agreement as to the direction of efforts.

The one study in the physical sciences dealt with an effort to develop a unit on atomic energy for the physical science survey. This would seem to indicate an effort, at least on the part of one investigator, to keep the content of the course current.

Content of Specialized Science

In direct contrast with the studies in general-education science, the studies in this area have been in the physical sciences with emphasis on chemistry at the college level. Most of them are "status studies" directed at determining the enrollments in, and contents of, specialized courses in chemistry. They indicate that enrollments in beginning chemistry may be as low as 5% in large universities and as high as 36% in small colleges. How many students continue with chemistry after the beginning course was not made clear. In general the studies of the contents of general chemistry, biochemistry and qualitative analysis indicate a systematic subject-matter centered approach in contrast with the functional approach of the survey courses. This approach does not seem consistent with the tests prepared by the American Chemical Society for certain of these courses—tests that emphasize knowledge and application of principles.

In summary, it seems that the biologists have taken greater cog-

nizance of the functional approach to science teaching than have the physical scientists.

Community Resources and Science Teaching

As in previous years, research studies in the use of community resources for teaching science were undertaken. However, the only published research in this period dealt with the use in elementary science of museums, marine environments, and government bulletins about fisheries and fisheries management. These studies only serve to substantiate what is already well-known. Practically any type of science-related experience will serve the goals of science instruction if it is properly used. While some experiences are more suitable for mature students, nearly any form of community resource will provide some satisfactory learning experience for any child.

It would seem reasonable to suggest that further study to ascertain the values of a community resource as a learning experience would be redundant. Research should be directed at developing principles, policies and methods for selecting and using the resources of the community most efficiently.

The Teaching and Learning of Science

Factors Influencing Achievement in Science

During the past several years, many investigators have undertaken studies that sought to identify the factors that influence achievement in science. A number analyzed the characteristics of students that influence the learning situation, while some have sought to analyze the factors in the learning situation. Many others have attempted to identify the elements involved in science talent. None of them, however, have produced startling results. In general, all the studies point to the fact that maturity, intelligence and motivation influence learning—a fact well known for many years. They show that more mature and intelligent students can (1) do demonstrations better, (2) analyze verbal abstractions better, (3) classify and index ideas more effectively, (4) apply principles better, and (5) give better scientific explanations of pictures than their less mature and less intelligent cohorts.

Efforts to determine why students in certain schools obtain more science awards than those in others, emphasize the importance of the factor of motivation—the motivation ordinarily consisting of opportunity for outside study and extra help from teachers.

Apparently, no one has yet been able to show that talent in science is greatly different from talent in certain other areas. A student of a high level of maturity and high general intelligence who is motivated

to study science will learn science better than one not so favored.

Prediction of Success in Science Work

Many studies have been undertaken to determine ways for preparing high school students for college science and for selecting those who seem to be the best prospects for advanced study in this area. Obviously, the three factors listed in the previous section are of prime importance. However, much has been done to try and determine the factors that enable one to select science students from among the more mature and intelligent.

A number of studies have attempted to determine the relationship between high-school preparation and success in science in college. They foster several conclusions that seem anomalous. Subject-matter tests given to college students show they retain very little of the topical material they learn in high school. Yet other studies show that students who have had science in high school invariably do better in college than those who have not. In addition the *general average* that a student obtains in high-school subjects seems to be a better criterion of success in college science than any other factor.

One may conclude, therefore, in so far as high-school grades are indicative of intelligence, that intelligent students do well in science in college. Further, although they forget much of the subject matter they learn in high school, they carry some residue from high-school science that enables them to function more efficiently in college science. Further study is needed to identify specifically this residue so that it may become an objective of greater emphasis in high-school science instruction.

Many studies have been undertaken to determine the extent to which scores on different standardized tests are predictive of success in college science. Some tests emphasize science subject matter, others mathematics, and some English ability. None have proved to be satisfactory for the intended purpose. Apparently this further substantiates the fact that science talent is affected by many factors other than those that seem logically identifiable. At present, the available standardized tests have not been able to identify the criteria desired.

Methodology in Science Teaching

Periodically a rash of studies appear that attempt to compare the relative values of different methodologies of science teaching. One such study at the high-school level compared the "textbook-centered" with the "laboratory-centered" methods of teaching chemistry. A number of college studies dealt with such factors as the problem approach for teaching general-education biology, student reactions to

group and lecture-discussion methods of teaching biological science, methods of coordinating quiz and lecture sessions in chemistry, demonstration and individual-laboratory methods in general physical science, and different amounts of laboratory and lecture time in teaching general chemistry.

These studies all point to the fact that the amount of contact that a student has with a learning situation is more important than the specific methodology used in that situation. This is consistent with the vast number of studies already undertaken in this area. All these studies point out that under proper conditions any methodology is effective in teaching if its potentialities are exploited properly. Apparently the success of any one method depends on its judicious use, and the way in which the various methods are used from time-to-time to vary the learning situation. It should seem reasonable to suggest, as has been suggested many times before, that studies comparing methodologies will show advantages and disadvantages with each, none being generally better than any other. More studies should be devoted to the determination of the optimal use of the respective methods.

Interests in Science

The factor of interest in science is one that is studied quite frequently. The facets studied include the areas of science in which children are interested, the time at which interests become stable, and the persons who seem to be most influential in interesting children in science.

The investigations here summarized substantiate but fail to extend the conclusions made about interests in previous reviews. It appears that the science interests of elementary children are not stabilized and are better described as "curiosities." Children are "interested" in the ephemeral and in areas that have popular appeal. They seem to be inspired by the spectacular. They like to study radio-activity, interplanetary travel, atomic energy and airplanes. They do not have any major "interest" in scientific laws or principles, published science materials or personal health problems. The major areas in which they profess "interest" are not generally emphasized in the textbooks they use. In so far as textbooks reflect the major objectives of science teaching, apparently children's interests are not consistent with them. It would seem therefore that the function of the teacher is to take the transient "interests" and use them in reaching the accepted objectives of science teaching, namely, the ability to understand and apply the major principles and laws of science, the development of habits of critical thinking, and skills in problems solving.

Studies show also that children who develop stable and long-term interests in science seldom show such ability before the junior-high-school level. It is interesting to note also that the person who inspires the long-term interest is likely to be the general-science teacher although the father is more likely to give the student suggestions for exploiting that interest. This suggests several interesting implications. Teachers of junior-high-school science are frequently inadequately trained to handle general science and often teach it as an extra subject during a "free period." The idea seems to be that "anyone can teach general science." Thus, while the child is likely to develop science interests at this level, teachers do little to exploit it either from lack of interest or ability. It would seem that much needs to be done to improve science teaching at this critical level.

Other studies show clearly that temporary interests are fostered at all levels by coping with the child's curiosities and concerns in science however ephemeral they may be and by providing out-of-school activities that give the child opportunity to experience science.

There is no direct evidence that clearly indicates the factors that are responsible for initiating interest, or the time at which it definitely becomes stable. However, it is well known that a well-trained teacher and opportunity to experience science help the nebulous concept of interest to mature and flourish.

Development of Scientific Attitudes

Two facets of attitudes have been studied, namely, the development of attitudes toward the study of science (probably related to interest), and the development of scientific attitudes (habits of critical thinking).

Several studies have attempted to determine the factors that are related to desirable attitudes *toward* the learning of science. In certain cases conflicting conclusions have been drawn. Some studies show that desirable attitudes are related to success in science courses, others fail to show such a relationship. Since none of the studies make clear the meaning of "attitude" it may be that different factors are being measured. Further the tests from which the data are obtained have low validities. Much still needs to be done in this area.

In the measurement of scientific attitudes it was found that boys are likely to grow more in scientific attitudes than girls, and rural students more than urban. However, the studies were nebulous with respect to the meaning of the term "attitude," the validity of the tests were suspect, and the increments in growth in attitudes too small to have major significance.

Another investigator attempted to measure growth in scientific

attitudes in students as a result of their analyzing textbook errors. No significant growth in attitude was found and students professed a dislike of the procedure anyway.

In general, these studies fail to provide any significant conclusions about growth in attitudes. They suggest only that much needs to be done in making objective and valid analyses of scientific attitudes.

Evaluating the Objectives of Science Instruction

During the last year a series of sixteen studies dealing with the New York State Regents Examinations in Science were completed. Such an investigation was long since needed in view of the fact that during the long history of the examinations such an evaluation had never been made. From the extensive findings the following general conclusions emerged: 1) The studies fail to show that the Regents Examinations in Science are distasteful to teachers as had been supposed. Most science teachers in the State seem to believe that the science program in New York State profits by their presence. 2) The examinations seem to be more reliable and valid than teacher-made tests and compare favorably with the commonly used standardized examinations in science. 3) In general, the examinations are not prejudicial to any particular group within New York State. While boys from the large high schools seem to have the greatest achievement, and girls from the small high schools the least, the superiority and inferiority were neither consistent nor especially marked. 4) It does seem that a better system for scoring the examinations is indicated. Apparently teachers have been "on their own" more than may be considered desirable, and as a result a number of irregular scoring practices have occurred. 5) The studies failed to suggest that the examinations should be abolished. While it was revealed that the system has weaknesses, the weaknesses are relatively the same as those that could be found in any mode of evaluation.

Suffice to say the evidence from this investigation is worthy of study by any person interested in evaluation of science instruction.

Several other studies have dealt specifically with the measurement of outcomes of logical reasoning and thinking as a result of work in college science. The data from the studies show that among zoology students there in much animistic thinking, and students in botany are able to recite information about plants without having a knowledge of its true significance, or of a significance of the true nature of life. Further, students do not have a sufficient grasp of principles of science to be selective of information needed for the explanation of scientific phenomena.

One attempt was made to show how teachers could develop classroom tests to measure critical thinking. The items were based on the

ability of the students to judge the relative truth or falsity of conclusions based on scientific statements. Such pilot studies need to be extended.

Another unique study in evaluation dealt with the judging of science exhibits prepared by students. The findings were that judges vary greatly in the factors used in their judgments and much needs to be done in developing score cards to estimate random influences.

In general much still needs to be done in evaluating with validity the objectives of science teaching.

The Parent and the Science Student

Recent studies have brought out a number of interesting conclusions about the relationship of parents to the science achievement of the student. Surprisingly, parents have a great deal more influence, and apparently more interest, than formerly suspected. With some limitations it can be stated that the areas of science a child studies in school become to some degree part of the parents' knowledges. Further, the father seems to foster the science interests of students more than any other person, including the teacher.

It is also noteworthy that the occupational backgrounds of parents have little to do with the science achievements of students. Apparently the parents of science students, no matter what their backgrounds, are valuable allies to the program of science instruction. In all probability their potentialities need further examination and exploitation.

Facilities for Science Instruction

Equipment for the School

Judging by the investigations in this area, the growth of elementary science has been accompanied by the lack of adequate supplies and equipment. It has been found generally that few elementary classrooms have access to water, heat or electricity. In many rooms equipment must be borrowed from the high-school laboratories. Hence several major studies have attempted to project enrollments into the future and estimate minimal needs per classroom and per student. By matching these needs with present supplies, and developing a rational procurement plan, a satisfactory compromise for science classrooms has been reached. These studies eminently merit the consideration of all persons involved in elementary-school administration.

Preparation of Guidance Materials for Science

The shortage of scientists and science teachers has prompted

organizations such as the AAAS and NSTA to prepare guidance materials for science students. In addition many industries have done likewise for their own special fields of interest. With a small amount of effort such materials can be located by writing the organizations concerned. The studies show that teachers have wanted such help for a long time. It is now available.

Scientists and Science Teachers

The Supply of Scientists and Science Teachers

For the past several years there has been a national concern and a number of research studies dealing with the steadily decreasing supply of scientists and science teachers. This decline is in direct contrast with a steadily increasing need. The dearth of these trained personnel is especially alarming since Russia now trains twice as many scientists each year as the United States and apparently has no shortage of science teachers.

The lack of both types of personnel is part of a common problem that tends to be self perpetuating. The low birthrate of the depression years 1930–1940 failed to provide the teachers needed to teach the skyrocketing number of children that were born during and after World War II. The lack of such teachers is especially marked in the scientific fields. Hence as science courses have been taught by fewer and less adequately trained personnel, students have become less interested in the subject. Fewer enroll in science in teacher-training institutions. Classrooms, as a result, become less adequately staffed. Consequently, the year 1955 saw 50% as many science teachers produced as in 1950.

A major report of the CASMT pointed out that difficulties are intensified by the fact that science is required less frequently than any other subject in the high-school curriculum, and guidance counselors are seldom trained in the scientific fields. Hence, students are not motivated to study the sciences as much as may be desirable.

The problem is now receiving major attack by the AAAS through the Science Teaching Emergency Program financed by a $300,000 grant from the Carnegie Corporation.

Training of Science Teachers

During the past several years a number of research studies have been undertaken to evaluate the status of science teaching in Michigan, Alabama, Illinois, California, Ohio, Minnesota, Virginia and Oklahoma.

The research evidence shows that ninety per cent of the teachers

whose major assignment is to teach science, teach subject combinations in these areas: (1) Physical education, biology and general science; (2) Chemistry, physics and mathematics; (3) Chemistry, physics and biology; (4) Biology and general science. The remaining ten per cent teach varied combinations of science as well as courses in other fields of subject matter. More than half of all teachers who teach science, teach only one class in science. Also in many of these schools, particularly the smaller ones, all science teachers teach courses other than science.

A survey of the various studies indicates that the assignment of teachers to teach general science is apparently governed by chance. Although general science involves the integration of biology, astronomy, earth science, health, chemistry, meteorology, physics and conservation, the persons who teach the course may be highly specialized in one area to the exclusion of training in the others, or may have little or no science in their backgrounds.

In many states persons majoring or minoring in physical education are expected to have minors in biology. As a result, about two-thirds of the classes in biology in these states are taught by persons whose major interest is not in the area of biology. In several states studied, about one-half of the teachers of physics had no background in physics other than the introductory course or an incidental survey course. Since the breadth and scope of modern physics is expanding steadily it would seem that the training of a teacher to teach physics should be both intensive and extensive in the area of physics. Further, since courses in chemistry include much material from the area of physics, and seventy per cent of the principles ordinarily taught in general science are related to the area of physics, it would seem that courses in physics would constitute at least part of the background of a teacher of any area of science. Yet in 1953 in one midwestern state not one student from any of the teachers colleges or universities who graduated with a major or minor in physics entered the teaching profession.

The problems just described are no less severe at the elementary level. In many schools the only science courses available to future teachers of elementary science are those designed for students intending to major or minor in biology, chemistry or physics.

It seems reasonable to suggest that colleges and universities involved in training science teachers should take a realistic look at the functions of science teachers in the field and should develop realistic programs for training them. Apparently, the training of teachers seems to have been an incidental consideration of many science divisions. As a result the situation just described has resulted.

Practices in the Science Classroom

Research studies show that the indifferent attitude toward science teaching is apparent in teaching practices as well as in the teacher-training programs. The evidence shows that in many classrooms the time devoted to audio-visual experiences, to demonstrations and to laboratory exercises is woefully little and in some cases *nil*. Some teachers spend little or no time in planning lessons either for lack of time or for indifference. There is a wide use of charts, models and pickeled specimens, when living materials could be obtained with little effort. Many science teachers belong to no professional science organizations (or fail to attend meetings if they do), read no professional journals, and undertake no advanced professional study except that necessary to maintain their teaching certificates or obtain monetary increments. While these situations do not apply to the majority of science teachers, they do apply to a minority whose actions do much to demoralize the profession.

Much research needs to be done to determine why these situations exist and particularly what can be done about them.

Training of Scientists

In addition to studies concerning the training suitable for science teachers, a number of studies have been undertaken to determine the optimal balance between general and special courses for training graduates for careers in chemistry. The general impression of the graduates seems to be that the training in chemistry is adequate but that the training outside the special field is not broad enough. They suggest the need for study of foreign languages to help them read foreign journals, a broader training in the field of physics, more functional courses in communications and better professional guidance especially at the undergraduate level. These suggestions seem to be in harmony with the need for greater breadth of training for science teachers. However, the studies in this general area are too few in number and too limited in scope to warrant generalized conclusions.

Professional Growth and Professional Contributions

Several studies have been reported recently with respect to the professional growth and professional contributions of those who enter science as a career. The situation is not worthy of great optimism. In so far as continued education is concerned, fewer than 3% of those who received bachelor's degrees in science go on through the doctor's degree. Once a person obtains a job in a college and teaches science his contributions frequently end. The percentage who contribute articles to professional journals or publish original research is in-

credibly small. Apparently such contributions depend on the initiative of the faculty member rather than on the reputation of the institution. In general the *per capita* contribution of the science faculty of small liberal-arts colleges is much greater than that of the science faculty of large colleges and universities. Again the data are too sparse to warrant conclusive statements.

Summary

To summarize what is already a summary would be redundant. However, the following observations seem reasonable:

1. Research workers in science education would do well to review the literature before undertaking studies. In many cases they contribute data in areas in which the evidence is already conclusive. In turn they by-pass many areas in need of further study.

2. Less research needs to be undertaken in which problems are identified while more needs to be done in seeking solutions to problems already evident.

SUMMER INSTITUTE FOR COLLEGE SCIENCE TEACHERS

The National Science Foundation is sponsoring a four-week institute for college teachers of physical sciences July 9-August 3, 1956, to be conducted by the Oak Ridge Institute of Nuclear Studies at its Special Training Division's facilities in Oak Ridge, Tennessee. The summer institute will present an up-to-date, comprehensive review of scientific developments, classical and modern, stressing that science should be taught and learned as a whole, rather than as a series of highly specialized and unrelated technologies.

Among tentative lecture topics planned are: classical and modern physics, chemistry, mathematics, science experiments, science teaching methods, and radioisotope techniques. No formal grant of academic credit is made by ORINS for participation in the summer institute.

The daily schedule of the institute will include three lecture hours in the morning and two each evening with the afternoons and weekends reserved for informal and unscheduled conferences, library work, experiments, visits to points of interest in Oak Ridge, and other educational activities.

Participating teachers, visiting lecturers, and their families will be offered housing in a single dormitory-type building with arrangements for the group to be together at meals.

Selection of participants will be made from applications of teachers of physical science in universities, colleges, and junior colleges. A letter of endorsement will be required from a responsible official of the school.

A stipend, including dependency allowance, applicable to traveling and living expenses, will be available for a limited number of participants. There is no fee for participation in the institute.

Application blanks and additional information may be obtained from Dr. Ralph T. Overman, Chairman, Special Training Division, Oak Ridge Institute of Nuclear Studies, P. O. Box 117, Oak Ridge, Tennessee.

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SOME OBSERVATIONS ON RIDING A BICYCLE

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I pose first a number of questions:

(1) When one is riding a bicycle in a straight line in a vertical plane and he feels himself tipping (to the *right*, say), why does he turn the front wheel to the *right?*

(2) When riding *without* hands on the handle bars why is *greater* speed needed for stability than when the hands are *on* the handle bars?

(3) Why, at high speeds, does the *slightest* motion of the handle bars preserve stability, while at slow speed *violent* turns of the front wheel are required?

In the discussion which follows we observe the rider from above, looking in the direction of motion.

Regarding the first question, it is clear that turning the front wheel instantly puts the bicycle into motion in a *curved* path. If, as experience shows, the tipping is now averted, some force must be born which rights the bicycle. This force must be centrifugal, arising from motion in the curved path. Since its action is to the left and on the center of gravity of the rider-bicycle system the bicycle is *pushed back* to the vertical.

Questions (2) and (3) involve the gyroscopic action of the front wheel. With *no* hands on the handle bars this gyroscopic action must obviously accomplish just what the rider would accomplish if he held the handle bars. Consider now the angular momentum of the front wheel. Its vector representation points left. As before, imagine the bicycle to tip to the right. The arrow end of the momentum vector moves up. This rate of change of the angular momentum vector is, by a fundamental theorem, equal to the moment of the forces acting. This moment vector points up. This implies the existence of a counterclockwise torque. An equal torque must now act on the wheel if it is to move straight ahead. Without hands on the handle bars then, the front wheel turns to the right and, as in Question (1), the centrifugal force is again born which rights the bicycle. If hands *were* on the handle bars the necessary couple would be provided by the rider's action to turn the front wheel to the left, whereupon it would go straight. Accordingly, then, greater speed is needed for stability when no hands are used than when the hands are on the handle bars. By the same line of reasoning Question (3) is answered.

INFORMAL GEOMETRY IN THE JUNIOR HIGH SCHOOL

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INTRODUCTION

The last time I taught a seventh grade class in mathematics I met the class (none of whom I had ever seen before) on the first day of school and asked the question "What would you like to study next?" The answer came back in unison at once "Anything but arithmetic!" Just so! No one is satisfied with anything but variety in his physical diet and so it is with his food for mental maturing. The trouble is that in many schools, in the past, we have given the students eight years of arithmetic. It's time for a change, and in many schools changes have been made. We ought to be able, with proper teaching, to give the students a good knowledge of the fundamental skills of integers and fractions, both common and decimal, by the end of the sixth grade. To be sure, we should continue to give applied problems all through the secondary school that would make it necessary for the student to refresh these skills at any time it is necessary, but that should not constitute the entire program in mathematics.

The meaning and purpose of informal geometry need not be discussed fully here, nor all of the various methods of approach in teaching informal geometry since I have discussed it fully elsewhere.[1] It may be interesting, however, to note that there is nothing really new about the idea or the methods used. They are something that good teachers have always employed. For example, the preface of *First Lessons in Geometry*, written by Thomas Hill in 1854, which is now out of print, reads in part as follows:

> I have long been seeking a Geometry for beginners, suited to my taste, and to my convictions of what is a proper foundation for scientific education. Finding that Mr. Josiah Holbrook agreed most cordially with me in my estimate of this study, I had hoped that his treatise would satisfy me, but, although the best I had seen, it did not satisfy my needs. Meanwhile, my own children were in most urgent need of a textbook, and the sense of their want has driven me to take the time necessary for writing these pages. Two children, one of five, the other of seven and a half, were before my mind's eye all the time of my writing; and *it will be found that children of this age are quicker of comprehending first lessons in Geometry than those of fifteen.*[2]
>
> Many parts of this book will, however, be found adapted, not only to children, but to pupils of adult age. The truths are sublime. I have tried to present them in simple and attractive dress.

[1] Reeve, William David. *Mathematics for the Secondary School. Its Content and Methods of Teaching and Learning*, Henry Holt and Company, New York, 1954. Chapter 6.

[2] The italics are Hill's.

I have addressed the child's imagination, rather than his reason, because I wished to teach him to conceive of forms. The child's powers of sensation are developed before his powers of conception, and these before his reasoning powers. This is, therefore, the true order of education; and a powerful logical drill, like Colburn's admirable first lessons of Arithmetic, is sadly out of place in the hands of a child whose powers of observation and conception have, as yet, received no training whatever. I have, therefore, avoided reasoning, and simply given interesting geometrical facts, fitted, I hope, to arouse a child to the observation of phenomena, and to the perception of forms as real entities.

Even as early as 1876 Herbert Spencer wrote the following letter to D. Appleton and Company, who were then about to republish in the United States a book called "Inventional Geometry" written by his father, William George Spencer. This book had already appeared in England:

London, June 3, 1876

Messrs. D. Appleton & Co.: I am glad that you are about to republish in the United States, my father's little work on "Inventional Geometry." Though it received but little notice when first issued here, recognition of its usefulness has been gradually spreading, and it has been adopted by some of the more rational science-teachers in schools. Several years ago I heard of its introduction at Rugby.

To its great efficiency, both as a means of producing interest in geometry and as a mental discipline, I can give personal testimony. I have seen it create in a class of boys so much enthusiasm that they looked forward to their geometry-lesson as a chief event in the week. And girls initiated in the system by my father have frequently begged of him for problems to solve during their holidays.

Though I did not myself pass through it—for I commenced mathematics with my uncle before this method had been elaborated by my father—yet I had experience of its effects in a higher division of geometry. When about fifteen, I was carried through the study of perspective entirely after this same method; my father giving me the successive problems in such order that I was enabled to solve every one of them, up to the most complex, without assistance.

Of course, the use of the method implies capacity in the teacher and real interest in the intellectual welfare of his pupils. But given the competent man, and he may produce in them a knowledge and an insight far beyond any that can be given by mechanical lesson-learning.

Very truly yours,
HERBERT SPENCER

The author himself wrote the following introduction for the American edition:

INTRODUCTION

When it is considered that by geometry the architect constructs our buildings, the civil engineer our railways; that by a higher kind of geometry, the surveyor makes a map of a country or of a kingdom; that a geometry still higher is the foundation of the noble science of the astronomer, who by it not only determines the diameter of the globe he lives upon, but as well the sizes of the sun, moon, and planets, and their distances from us and from each other; when it is considered also, that by this higher kind of geometry, with the assistance of a chart and a mariner's compass, the sailor navigates the ocean with success, and thus brings all nations into amicable intercourse—it will surely be allowed that its elements should be as accessible as possible.

Geometry may be divided into two parts—practical and theoretical: the practical bearing a similar relation to the theoretical that arithmetic does to algebra.

And, just as arithmetic is made to precede algebra, should practical geometry be made to precede theoretical geometry.

Arithmetic is not undervalued because it is inferior to algebra, nor ought practical geometry to be despised because theoretical geometry is the nobler of the two.

However excellent arithmetic may be as an instrument for strengthening the intellectual powers, geometry is far more so; for as it is easier to see the relation of surface and of line to line, than of one number to another, so it is easier to induce a habit of reasoning by means of geometry than it is by means of arithmetic. If taught judiciously, the collateral advantages of practical geometry are not inconsiderable. Besides introducing to our notice, in their proper order, many of the terms of the physical sciences, it offers the most favorable means of comprehending those terms, and impressing them upon the memory. It educates the hand to dexterity and neatness, the eye to accuracy of perception, and the judgment to the appreciation of beautiful forms. These advantages alone claim for it a place in the education of all, not excepting that of women. Had practical geometry been taught as arithmetic is taught, its value would scarcely have required insisting on. But the didactic method hitherto used in teaching it does not exhibit its powers to advantage.

Any true geometrician who will teach practical geometry by definitions and questions thereon, will find that he can thus create a far greater interest in the science than he can by the usual course; and, on adhering to the plan, he will perceive that it brings into earlier activity that highly valuable but much-neglected power, the power to invent. It is this fact that has induced the author to choose as a suitable name for it, the "inventional method" of teaching practical geometry.

He has diligently watched its effects on both sexes, and his experience enables him to say that its tendency is to lead the pupil to rely on his own resources, to systematize his discoveries in order that he may use them, and to induce gradually such a degree of self-reliance as enables him to prosecute his subsequent studies with satisfaction; especially if they should happen to be such studies as Euclid's "Elements," the use of the globes, or perspective.

A word or two as to using the definitions and questions. Whether they relate to the measurement of solids, or surfaces, or of lines; whether they belong to common square measure, or to duodecimals; or whether they appertain to the canon of trigonometry; it is not the author's intention that the definitions should be learned by rote; but he recommends that the pupil should give an appropriate illustration of each as a proof that he understands it.

Again, instead of dictating to the pupil how to construct a geometrical figure —say a square—and letting him rest satisfied with being able to construct one from that dictation, the author has so organized these questions that by doing justice to each in its turn, the pupil finds that, when he comes to it, he can construct a square without aid.

The greater part of the questions accompanying the definitions require for their answers geometrical figures and diagrams, accurately constructed by means of a pair of compasses, a scale of equal parts, and a protractor, while others require a verbal answer merely. In order to place the pupil as much as possible in the state in which Nature places him, some questions have been asked that involve an impossibility.

Whenever a departure from the scientific order of the questions occurs, such departure has been preferred for the sake of allowing time for the pupil to solve some difficult problem; inasmuch as it tends far more to the formation of a self-reliant character, that the pupil should be allowed time to solve such difficult problems, than that he should be either hurried or assisted.

The inventive power grows best in the sunshine of encouragement. Its first shoots are tender. Upbraiding a pupil with his want of skill, acts like a frost upon him, and materially checks his growth. It is partly on account of the dormant state in which the inventive power is found in most persons, and partly that very

young beginners may not feel intimidated, that the introductory questions have been made so very simple.

Note also the following list of books similar to Hill's, written since 1850, which are representative of the idea that informal geometry has a place in the early stages of the secondary school:

1. Campbell, W. T., *Observational Geometry*, American Book Company, New York, 1899.
2. Coates, J. V. H., *A First Book of Geometry*, Macmillan and Company, London, 1912.
3. Failor, I. N., *Inventional Geometry*, The Century Company, New York, 1904.
4. Fowler, C. W., *Inductive Geometry*, published by the author, 1905.
5. Hill, G. A., *A Geometry for Beginners*, Ginn and Company, Boston, 1880.
6. ———. *Lessons in Geometry*, Ginn and Company, Boston, 1887.
7. Hill, Thomas. *First Lessons in Geometry*, Wm. Ware and Company, Boston, 1855.
8. ———. *Second Book in Geometry*, Ginn and Company, Boston, 1863.
9. Hornbrook, A. R. *Concrete Geometry*, American Book Company, New York, 1895.
10. Hunt, E. *Geometry for Grammar Schools*, D. C. Heath and Company, Boston, 1894.
11. MacDonald, J. W. *Geometry in the Secondary School*, Williard Small, Boston, 1889.
12. Marks, Bernard. *First Lessons in Geometry*, Blakeman, Taylor and Company, New York, 1871.
13. Mault, A. *Natural Geometry*, Macmillan and Company, London, 1877.
14. Nichols, E. H. *Elementary and Constructional Geometry*, Longmans, Green and Company, New York, 1902.
15. Row, T. S. *Geometric Exercises in Paper Folding*, Open Court Publishing Company, Chicago, 1905.
16. Shaw, W. N. (Mrs.). *First Lessons in Observational Geometry*, Longmans, Green and Company, New York, 1903.
17. Wentworth, G. A. and Hill, G. A. *First Steps in Geometry*, Ginn and Company, Boston, 1901.
18. Wright, D. S. *Exercises in Concrete Geometry*, D. C. Heath and Company, Boston, 1907.

If the content material of informal geometry is difficult for the learner, the textbooks or teacher, or both, are likely at fault. We know that students differ in abilities, in experiences, and in interests, but it is difficult to believe that a normal student and even some of the duller normal students cannot profit greatly by the study of informal geometry. However, if the learner is not interested for some reason or other, or does not understand the earlier stages in the study of geometry, a poor foundation is being laid for the superstructure that comes in demonstrative geometry, to say nothing of the loss in knowledge of the subject *per se*.

Nunn made some interesting comments upon what he considered fundamental stages in a student's development. He said:

I assume as common ground that the school course in geometry should show two main divisions: (1) a heuristic stage in which the chief purpose is to order and clarify the spatial experiences which the pupil has gained from his everyday intercourse with the physical world, to explore the more salient and interesting

properties of figures, and to illustrate the useful applications of geometry, as in surveying and "Mongean" geometry; (2) a stage in which the chief purpose is to organize into some kind of logical system the knowledge gained in the earlier stage and to develop it further. In the first stage obvious truths (such as the transversal properties of parallel lines) are freely taken for granted, and deduction is employed mainly to derive from them important and striking truths (such as the constancy of the angle-sum of a triangle) which are not forced upon us by observation. The second stage is marked by an attempt, more or less thoroughgoing and "rigorous," to explore the connexions between geometrical truths and to exhibit them as the logical consequences of a few simple principles.[3]

David Eugene Smith used to say that "Informal geometry is the fish course of the mathematical dinner served in the seventh grade." There is a large field of interest here. If it is all interest and of no use, we should not teach it and if it is all useful but not interesting, we should not teach it. We must have a proper balance. This can be obtained by properly answering the three questions that one can ask about an object in geometry:

1. What is its shape? (Form)
2. What is its size? (Size)
3. Where is it? (Position)

Perhaps the correct and logical order of these questions is 3, 1, and 2.

We are not concerned in geometry with the cost of the object, its odor, its color, or of what material it is made. We do not need to use proofs. We get our principles simply by observing objects. Most of these objects will be known by the students in the first grade of school. But there is an upper limit. Few students would know hyperbola, some might know the ellipse because of the many elliptic stadia in the world, and a few perhaps the parabola, but they are not likely to be of great interest in the seventh grade.

Poincare denied that certainty can come from intuition, but he gave it a prominent place in the teaching of mathematics. He said:

I have already had occasion to insist on the place intuition should hold in the teaching of the mathematical sciences. Without it young minds could not make a beginning in the understanding of mathematics; they could not learn to love it and would see in it only a vain logomachy; above all, without intuition they would never become capable of applying mathematics.

The tendency of the modern pure mathematician, especially since the critical investigation of the foundations of Euclid (particularly his parallel postulate), has been to reduce the use of intuition to a minimum. Since the subject of geometry has been considered a commingling of intuition, "the instrument of invention," and logic, "The instrument of demonstration," with the latter predominating, it seems safe to give each an important role in teaching geometry. This attitude is not unscientific.

[3] Nunn, T. P. "The Sequence of School Theorems in Geometry," *The Mathematics Teacher*, October, 1925, 18: 321–332.

Mathematics owes its great forward steps to the intuition of its giants. Indeed, the position of pure logic may not be so firm as we usually assert, and these words of the Dutch mathematician Brower may be more significant than we ordinarily admit:

In human understanding there is no logic; in mathematics it is not certain whether all logic has validity, and it is not certain whether it can be decided, whether or not all logic has validity.

For example, upon what does the *reductio ad absurdum* (Indirect method of proof) rest if not upon intuition?

Carson defines intuition as "merely a particular class of assumptions or postulates, such as form the basis of every science." He said:

It is this type of exercise in drawing and measurement which I regard as an attack upon intuition. It replaces this natural and inevitable process by hasty generalization from experiments of the crudest type. Some advocates of these exercises defend them on the ground that they lead to the formation of intuitions, and that the pupils were not previously cognizant of the facts involved. But in the first place, a conscious induction from deliberate experiments is not an intuition; it lacks each of the special elements connoted by the term.[4]

The Case for Informal Geometry

Betz made a good case for informal geometry when he said:

For generations the mathematical program of the elementary school has been limited almost entirely to arithmetic. Only the higher grades constituted an exception to the extent that it was customary to include some work in practical mensuration. This arrangement overlooked the fact that mathematics has a dual foundation—arithmetic and geometry. Number and form, counting and measuring, appeared on the scene together, for number was the indispensable tool of measurement, and considerations of shape, size and position accompanied even the primitive artisan in all his practical activities. Thus it was that the geometry of everyday life, often called intuitive or informal geometry, preceded the development of demonstrative geometry by thousands of years. And it is this kind of everyday geometry which we must have as one of the cornerstones of the mathematical edifice. Its virtual omission has given us the lopsided, distorted curriculum to which may be traced many of our mathematical troubles in the high school.

The arrival of the junior high school movement marked the beginning of a more serious effort to restore the "missing link" of mathematics to its rightful place, especially since the appearance of the National Report of 1923. Slowly, and often in very imperfect fashion, the necessary geometric material began to make itself felt in the textbooks and syllabi. But a great deal of improvement is still necessary. The war situation may well mark a turning-point in our notorious indifference to the claims of geometric instruction. All pre-induction syllabi in mathematics have stressed the essential character of a dependable geometric training. They demand a knowledge of geometric forms and concepts, skill in direct and indirect measurement, familiarity with basic constructions, with scale drawing, blueprint reading, map reading, and the like. For nearly a century American mathematical leaders have demanded a coordination of geometry and arithmetic. That step has long been taken by all other leading nations. We cannot afford to postpone it any longer in our American Schools.[5]

[4] Carson, G. St. L. *Essays on Mathematical Education*, Ginn and Company, 1913. Chapter 2 on "Intuition," p. 21.

[5] Betz, William.

The First Lesson in Informal Geometry

Wherever informal geometry is taken up in the seventh grade, the first lesson should be one that will at once arouse the interests of the students. This is a prime requisite in any approach to a new subject. If logical order were followed, one might begin with the geometry of position. It is likely, however, that most teachers will prefer to begin with the geometry of form. Even if this topic is selected, there are several ways in which to begin. We may begin the work, as many teachers do, with a discussion of primitive methods of shelter, or we may start with a simplified discussion of other spaces than ours, starting with pointland and running through the extensions of lineland, flatland, and so on.

To make the matter more definite the outline of one of the various methods is given in Chapter 4, pp. 108–115 of a recent book.[6] This lesson has proved to be very interesting and enjoyable to students and it provides a basis for a discussion of the geometry of form.

The teacher may find it helpful to organize subject matter around certain units.[7] For example, one might take the triangle and develop the idea of unity somewhat as follows:

1. Explanation of meaning.
2. Related symbolism or notation.
3. Classification by types on basis of
   a. Angles.
   b. Sides.
4. Measurement.
5. Applied problems.

Summary of Abilities To Be Developed

The following summary of abilities to be developed in informal geometry may be useful for reference:

The following general abilities should be developed:

1. The ability to:
   a. Use the common measures of length, area, and volume.
   b. Use the metric measures of length, limited to the kilometer, meter, centimeter, and millimeter; area, limited to the squares of the units of length; and volume, limited to the cubic meter, cubic centimeter, and cubic millimeter. The decimeter will naturally be mentioned, but as a unit of linear measure it is not so important as the others.
   c. Read a line segment lettered in either of two convenient ways.
   d. Read an angle lettered in any one of three convenient ways.
   e. Measure a line segment with a ruler, the result being accurate to the

[6] Reeve, William David. *Mathematics for the Secondary School, op. cit.*

[7] Gorges, H. S. "Units of Instruction in Secondary Mathematics," *Eighth Yearbook*, National Council of Teachers of Mathematics, *The Teaching of Mathematics in the Secondary School, 1933*, pp. 244 ff.

See also Zant, J. J. *The Teaching Plan for the Unit of Work in Junior High School Mathematics*, Cooperative Publishing Company, Guthrie, Oklahoma, 1934.

nearest tenth or sixteenth of an inch, or to the nearest millimeter, depending upon which scale is used.
- f. Measure a line segment by using dividers (compasses) to transfer its length to a ruler.
- g. Find approximate distances on the floor or out of doors by means of pacing.
- h. Use squared paper for the purpose of finding the length of line segments transferred to it by the dividers (compasses), and the area of plane figures drawn upon it to scale.
- i. Add one line segment to or subtract it from another.
- j. Measure an angle by means of a protractor.
- k. Given two similar figures, use proportion to compute any side when sufficient data are known.
- l. Measure the height of an object by shadow reckoning, using proportion.
- m. Measure the distance to an inaccessible object by means of a scale drawing or else by proportion.
- n. Locate a place by using a horizontal and a vertical axis, as in longitude and latitude.

The following abilities in drawing and constructing should be developed:

1. *Ability to:*
   - a. Distinguish between drawing (either freehand or with the ruler and protractor) and construction (with only the ruler and compasses).
   - b. Understand a scale drawing or a simple plan of one or more rooms of a building.
   - c. Understand the meaning of a map drawn to scale.
2. *Ability to draw the following figures, using the ruler, protractor, and, if convenient, a draftsman's triangle:*
   - a. A line segment of given length.
   - b. An angle of a given number of degrees.
   - c. A right angle.
   - d. A line parallel to a given line.
   - e. A square with the sides of a given length.
   - f. A rectangle of any convenient size.
3. *Ability to perform the following constructions with a ruler and a pair of compasses:*
   - a. Construct a circle with a given radius.
   - b. Bisect a given arc.
   - c. Bisect a given angle.
   - d. Bisect a given line.
   - e. Construct a right angle.
   - f. At a given point on a given line construct a perpendicular to the given line.
   - g. From a given point outside a given line construct a line perpendicular to the given line.
   - h. From a given point outside a given line construct a line perpendicular to the given line.
   - i. Divide a given line segment into a given number of equal parts.
4. *Ability to construct the following figures, using only a ruler and a pair of compasses:*
   - a. An equilateral triangle having a given side.
   - b. An isosceles triangle having the base and one of the equal sides given.
   - c. An angle equal to a given angle.
   - d. A line parallel to a given line.
   - e. An angle equal to the sum of two given angles or to the difference be-

tween two given angles.

f. A regular hexagon inscribed in a circle.
g. A square inscribed in a circle.
h. An equilateral triangle inscribed in a circle.
i. A triangle having two sides and the included angle given.
j. A triangle having two angles and the included side given.
k. A triangle having the three sides given.
l. A square having a given side.
m. A rectangle having two adjacent sides given.
n. The center of the circle of which an arc is given.
o. Angles of 30°, 45°, and 60°.
p. The perpendicular bisectors of the sides of a triangle.
q. The bisectors of the angles of a triangle.
r. The perpendiculars from the vertices of a triangle to the opposite sides.
s. The medians of a triangle.
t. A copy of a given geometric design.

The ability to make each of the following correct inferences should be developed:

1. *Ability to make correct geometric inferences with respect to such simple cases as the following:*
   a. The congruence of triangles.
   b. The alternate angles formed by a transversal cutting two parallel lines.
   c. The sum of the interior angles of a triangle.
   d. The parallelism of two perpendiculars to the same line.
   e. The similarity of triangles having the three angles of one respectively equal to the three angles of the other.

Important Concepts in Informal Geometry

The following important concepts in informal geometry should be developed:

Altitude
Angle, acute
  bisector
  of depression
  of elevation
  obtuse
  size of an
  straight
Angles, adjacent
  alternate
  complementary
  corresponding
  equal
  interior
  made by a transversal
  supplementary
  of a triangle
  unequal
  vertical
Arc
Area
Axis of symmetry
Base, of a polygon
  of a solid
Bisector, of an angle
  of a line
  perpendicular
Center of a circle
Center, of a regular polygon
Central angle
Circle
Circumference
Compasses
Complement
Cone
Congruence
Construction of a figure
Cube
Curve
Curve surface
Cylinder
Degree, angular
Diagonal of a polygon
Diagonal of a solid
Diameter
Direction
Distance
Ellipse

Equality
Figures, congruent
 geometric
 similar
 symmetric
Formula
Height of a plane figure
Height of a solid
Hemisphere
Hexagon
Hypotenuse
Length
Line, broken
 curve
 horizontal
 segment
 slanting
 straight
 vertical
Lines, equal
 oblique
 parallel
 perpendicular
 proportional
Measurement
Metric system
Midpoint
Octagon
Pantograph
Parallel
Parallelogram
Pentagon
Perimeter
Perpendicular
Pi (π)
Plane
Point
Polygon
Position
Prism
Proportion
Protractor
Pyramid
Quadrilateral
Radius, of a circle
 of a cone
 of a cylinder
 of a regular polygon
 of a sphere
Ratio
 of circumference to diameter
Rectangle
Rectangular solid
Rhombus
Root, square
 cube
Ruler
Scale drawing
Section
Sector
Semicircle
Side, of an angle
 of a polygon
Similarity
Size
 of an angle
Solid
 rectangular
Sphere
Square
Straight angle
 line
Supplement
Surface, curve
 plane
Symmetry
Transversal
Trapezoid
Triangle, acute
 general
 equilateral
 isosceles
 obtuse
 right
Triangles, congruent
 similar
Vertex, of an angle
 of a cone
 of a polygon
 of a solid
 of a triangle
Volume

THE CONSTRUCTION OF SPECIAL SLIDE RULES AND NOMOGRAPHS FOR THE TEACHER OF GENERAL CHEMISTRY. I. SPECIAL SLIDE RULES

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Over a period of many years the author has given much thought to a liberal use of unknowns in general chemistry[1] and to methods and devices that would promote individual responsibility on the part of the student.[2] Among these devices have been numerous special slide rules and nomographs which have made it possible to check homework problems individually assigned to large beginning classes and to issue and check individual laboratory unknowns of a quantitative nature. It is scarcely necessary to point out that this sort of rigorous procedure lends encouragement to serious scholarly endeavour and helps to identify the student who lacks interest or ability. In the discussion that follows the application of special slide rules to laboratory unknowns will be emphasized but it is believed that the reader will be able to readily adapt similar methods to individual homework problems.

SOME FUNDAMENTAL CONSIDERATIONS

The principle of the slide rule is a very simple one and involves the mechanical addition (or subtraction) of two lengths by sliding a movable scale over a fixed scale as illustrated in Figure 1a. If the zero of the moving scale (scale *C*) is placed directly above 3 on the *D* scale, 3 is added to any number on the *C* scale and the sum is found directly below on the *D* scale, e.g., 4 on the *C* scale plus 3 on the *D* scale equals 7 (on the *D* scale directly below 3). In a similar manner, the difference between any number on the *D* scale and the number directly above it on the *C* scale is 3. While the principle involved is sound, such an arrangement for addition (or subtraction) requires very long scales as the numbers become larger and the method quickly becomes impractical.

On the other hand, the scale length can be limited to a practical, convenient value if, instead of actual lengths, lengths proportional to logarithms[3] are used. This is so because the scale repeats itself

[1] Lyman J. Wood and Seward E. Owen, SCHOOL SCIENCE AND MATHEMATICS, 27, 919–25 (27).

[2] Lyman J. Wood, *Jour. Chem. Ed.*, 3, 1313–20 (26).

[3] A system of logarithms was invented by John Napier, Baron of Merchiston in 1614.[4] Napier died April 4, 1617 but before his death he had started to calculate a table of base 10 logarithms which was finished by his friend Henry Briggs, professor of mathematics at Gresham College, which table was published in 1618. The system of natural logarithms (usually attributed to Napier) was invented by John Speidel and his table of "New Logarithms" was published in London in 1619 (about two years after the death of Napier). The base of the natural logarithm system is $(1+1/n)^n$ when n becomes indefinitely great. This is an exceedingly important quantity for the student of the calculus and is represented by the Greek letter ϵ (epsilon) or the English letter e.

with each multiple of 10, i.e., the scale between 1 and 10 is precisely the same as between 10 and 100 which in turn is the same as between 100 and 1000. The same scale can be used for multiplying (of dividing) by numbers between 1 and 10, and 10 and 100 or 100 and 1000 provided only that in the end a proper accounting of the decimal point be made.

The usual length of the slide rule is 25 centimeters—the so-called 10 inch rule. Now the logarithm of 2 is 0.301 and the logarithm of 6 is 0.778 and the distance plotted for 2 is $0.301 \times 25 = 7.52$ centimeters and the distance plotted for 6 is $0.778 \times 25 = 19.45$ centimeters (Figure 1b). The distances 7.52 and 19.45 are logarithmic distances but for convenience they are labeled 2 and 6 respectively and the remainder of the scale is made up in the same way. It will be seen, that in this case, logarithmic distances are added and that these sums represent products. For example, with the beginning of the *C* scale over 3 on the *D* scale it is found that $\log 2 + \log 3 = \log 6$ but because the sum of two logarithms is equal to the logarithm of the product[6] of these two numbers we may write $2 \times 3 = 6$ and it is to be seen that

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The quantity can be evaluated by direct calculation.[5] When $n=2$, $(1+1/2)^2 = 2.25$; $n=5$, $(1+1/5)^5 = 2.489$; $n = 10,000$, $(1+1/10,000)^{10,000} = 2.7182$. As n becomes larger ϵ becomes larger but it increases at a very slow rate. It is more practical to evaluate $(1+1/n)^n$ by means of the binomial theorem. When n is very large this expansion becomes

$$\epsilon = 1 + 1 + \frac{1}{\underline{|2}} + \frac{1}{\underline{|3}} + \frac{1}{\underline{|4}} \cdots \quad (1)$$

This is a rapidly convergent series and can be used for getting ϵ to any desired accuracy (ϵ is incommensurable with 1 and is an interminable, non-recurring decimal. If 10 terms are used in this series $\epsilon = 2.718281$. When worked out to 21 decimal places

$$\epsilon = 2.718281828459045235360+$$

The quantity ϵ can readily be raised to any power, fractional or whole number. Writing $\epsilon^x = [(1+1/n)^n]^x = (1+1/n)^{nx}$ the binomial theorem is again used for expansion and when n becomes infinitely great

$$\epsilon^x = 1 + x + \frac{x^2}{\underline{|2}} + \frac{x^3}{\underline{|3}} + \frac{x^4}{\underline{|4}} \cdots$$

It is to be noted that x is the natural logarithm ($\log_\epsilon$) of the quantity on the right hand side of the equation. It is also possible to assign some predetermined value such as n to the right hand side and calculate the value of x. If this is done,

$$\log_\epsilon n = x = \frac{n-1}{n} + \frac{1}{2}\left(\frac{n-1}{2}\right)^2 + \frac{1}{3}\left(\frac{n-1}{3}\right)^3 \cdots \text{ when } n > 1/2. \quad (2)$$

If n be 100 we find, by the use of equation 2 that $\log_\epsilon 100 = 4.6052 \cdots$ whereas log 100 on the ordinary base 10 system is 2. We therefore may write

$$10^2 = 100 = \epsilon^{4.6052} \cdots$$
$$10 = \epsilon^{(4.6052/2)}$$

Using this ratio, a table of base 10 logarithms can be calculated. So important is this ratio that it has been worked out to at least 24 decimal places!

[4] U. S. Coast and Geodetic Survey (Treas. Dept.) Report for 1896—Appendix No. 12.

[5] *Calculus Made Easy.* Thompson, The Macmillan Company, 1927.

[6] If $a \times b = c$, then $\log a + \log b = \log c$. In the general case it is known that the product of m^x and m^y is equal to $m^{(x+y)}$ and m can be considered as the base for a system of logarithms. If it be assumed that $a = 2 = m^x$ and that $b = 3 = m^y$, then $c = 6 = m^{(x+y)}$. Because the case is general, we may choose some value for m such as 1.5 (this could be 1.4 or 1.6 or some other value). If m be set equal to 1.5, then $1.5^x = 2$, $1.5^y = 3$ and $1.5^{(x+y)} = 6$. Let the problem be to evaluate x and y and show that $1.5^x \cdot 1.5^y = 1.5^{(x+y)}$. By the use of an ordinary table of base 10 logarithms the solution is very simple, e.g., $(\log 1.5)x = 2$ and $x = 0.301/0.176 = 0.171$ (about). But, because an

any number on the D scale is three times the corresponding number on the C scale. To multiply 2×30 (or 300 or 3000) write $2\times3\times10$, add the logarithmic distance 2 to the logarithmic distance 3 as before, read off 6 as before and then multiply by 10 (or 100 or 1000) by adjusting the decimal point.

Approximately half of the C scale of Figure 1b extends to the right out of the drawing. To multiply 3 by 7 it would appear to be necessary to extend the D scale so that 21 would be under 7 (out of the drawing) on the C scale but such is not the case. It is only necessary to move scale C to the left so that its right hand end is over 3 on the D scale as shown in Figure 1c. It is true that 7 on the C scale is now over 2.1 on the D scale but by shifting the decimal point, 2.1 readily becomes 21 (or 210 or 2100). To divide it is only necessary to place a number on the C scale (the divisor) over a number on the D scale (the dividend) and read the quotient on the D scale directly under the end of the C scale (either the left hand or right hand end of the C scale, which ever one happens to be above the D scale). It is thus to be seen that it will never be necessary to reset the C scale when dividing as it often is in multiplying. (Reseting the C scale in multiplying can be avoided if logarithms of reciprocals are plotted somewhere on the C scale and this is often done, even on some very inexpensive slide rules.)

Some Special Slide Rules

Four special cases will be treated as follows:

a. There is a constant ratio between the C and D scales.
b. Only limited portions of the C and D scales are required.

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attempt is being made to look at some basic fundamentals, let it be required that the solution be reached without the use of logarithms.

By inspection it is to be seen that x is greater than 1 and less than 2 because $1.5^2=2.25$ but to evaluate x more precisely the unusual properties of ϵ described in footnote 3 above will be utilized. Let $\epsilon^z=2=1.5^x$ and let $\epsilon^r=1.5$ from which we can write

$$\epsilon^z=2=1.5^x=(\epsilon^r)^x=\epsilon^{rx} \quad \text{and} \quad rx=z$$

Now z and r can be readily evaluated by the use of equation 2 of footnote 3 which gives

$$z=\frac{2-1}{2}+\frac{1}{2}\left(\frac{2-1}{2}\right)^2+\frac{1}{3}\left(\frac{2-1}{2}\right)^3\cdots=0.6667 \text{ (about) and}$$

$$r=\frac{1.5-1}{1.5}+\frac{1}{2}\left(\frac{1.5-1}{1.5}\right)^2+\frac{1}{3}\left(\frac{1.5-1}{1.5}\right)^3\cdots=0.4023 \text{ (about)}$$

As more terms are used in the expression, z approaches 0.6931 and r approaches 0.4055 and $x=0.6931/0.4055=1.71$ (about) which is the value for x calculated by means of base 10 logarithms above. In a similar manner y is found to be equal to 2.71 when $1.5^y=3$ and if our fundamental equation be true we have

$$1.5^{1.71}\cdot1.5^{2.71}=1.5^{(1.71+2.71)}=1.5^{4.42}=6$$

The last equality can be checked by again using the unusual properties of ϵ. Remembering that $1.5=\epsilon^r=\epsilon^{0.4055}$ we may write $1.5^{4.42}=(\epsilon^{0.4055})^{4.42}=\epsilon^{0.4055\times4.42}=\epsilon^{1.792}$. When $\epsilon^{1.792}$ is evaluated by means of equation 1 of footnote 3 it is found that $\epsilon^{1.792}=6$ (nearly). The use of base 10 logarithms can now be fully appreciated because if some other system of logarithms such as base m or base ϵ were used the scales would no longer repeat themselves with each multiple of 10.

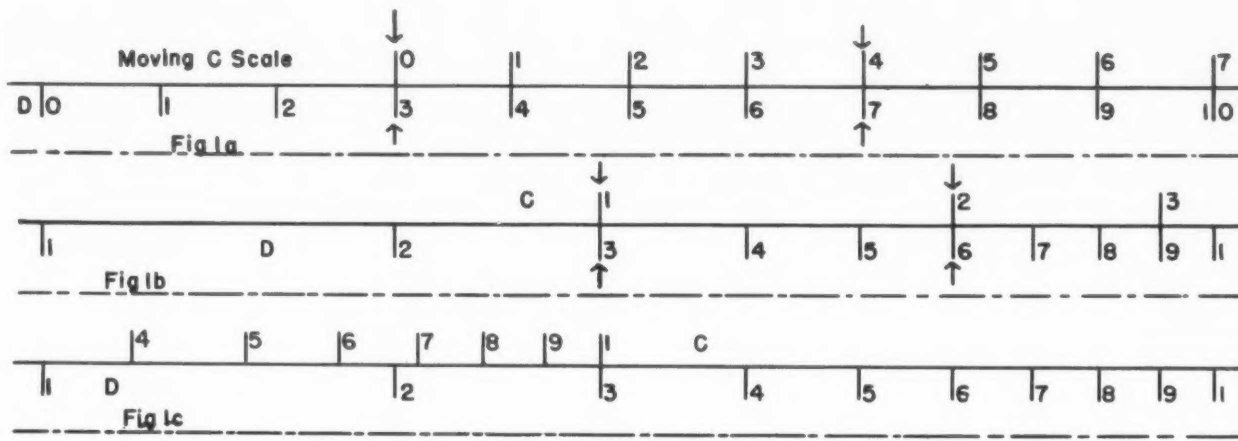

FIG. 1a. The beginning of a slide rule that could accomplish the mechanical addition of small numbers. As the numbers become larger the lengths of the scales very quickly become too long to be practical.

FIG. 1b. Showing a slide rule that can add logarithmic distances. Because the logarithm of a product is equal to the sum of the logarithms of its factors, this rule can be used for multiplication (or division).

FIG. 1c. The part of the *C* scale that extends out of the drawing in Figure 1b is shown here.

c. The relation between *C* and *D* is something other than a direct proportion.
d. Some combination of *a*, *b* and *c* is used.

Suppose the readings on the *D* scale are always to be three times the readings on the *C* scale (Figures 1b and 1c). In this case it is very easy to cut off the end of the C scale extending to the right out of the diagram in Figure 1b (use a fine jeweler's saw) and to insert it into the left hand end of the rule (combine Figures 1b and 1c). If the ratio is to have permanently only one value the ends of the sliding scale should be glued into place. If there is a possibility that the ratio may be a little greater or a little less on different occasions (it might be greater on warm days and less on cool days) this contingency can easily be met by making the sliding scale a little longer than 25 centimeters and extending the scale a sufficient amount in each direction. If the ratio will never be less than 2.5, the *C* scale must be extended to the right to read 4 (cut the scale off at 4 instead of $3\frac{1}{3}$ as before). If the ratio will never be more than 3.5, the *C* scale must be extended to the left until it reads 2.86 instead of $3\frac{1}{3}$ as before. In this case the two ends will have to be fastened together and the scale must of course remain movable so that the ratio can be set anywhere between 2.5 and 3.5. Suggestions for making such an extended scale are given below under Drawing and Construction.

A number of *C* scales can be compared simultaneously with one *D* scale as shown in Figure 2a. This set of scales is based on calculations required for a simple laboratory experiment[7] but could be used equally well with individually assigned homework problems. In the experiment chlorine is to be generated by the reaction of concentrated hydrochloric acid on manganese dioxide which is then absorbed in a strong solution of potassium hydroxide. It is assumed that all of the chlorine is absorbed and that the stoichiometric relations are represented by the equations

$$MnO_2+4HCl \rightarrow MnCl_2+Cl_2+2H_2O$$

$$Cl_2+2KOH \rightarrow KCl+KClO+H_2O$$

Let a given number of grams of potassium hydroxide (a different number for each student) be assigned. Problem: Calculate the grams of manganese dioxide and the grams of hydrogen chloride required to produce an amount of chlorine equivalent to the grams of potassium hydroxide taken; calculate the milliliters of concentrated hydrochloric acid to furnish the hydrogen chloride required (in this case it was assumed that the concentrated hydrochloric acid was 40

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[7] *Experimental Chemistry for Beginners.* Wood. Copyright by Lyman J. Wood, 1947.

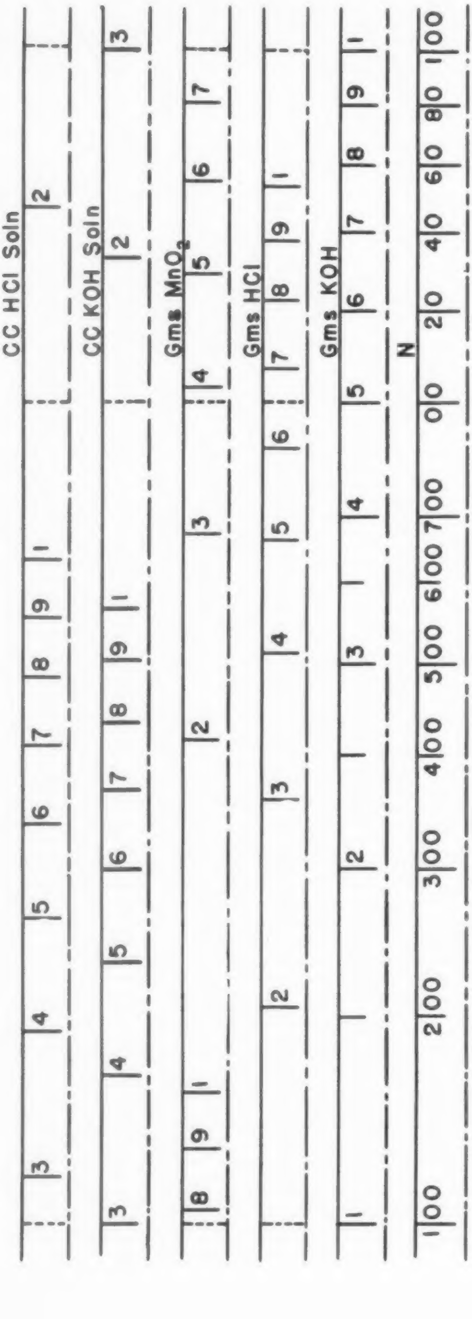

FIG. 2a. Showing the simultaneous comparison of several fixed ratio C scales with the D scale. The relation of the N scale to the D scale is not a direct proportion. The scale is labeled with values of N but the distances are proportional to $(0.05N+5)$.

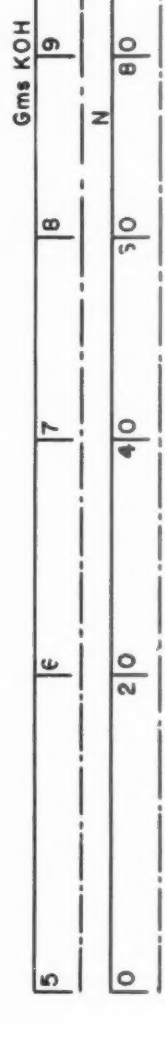

FIG. 2b. A part of Figure 2a has been expanded by a factor of 3. For purposes of illustration only part of the scales have been expanded. The others could of course be expanded in a similar manner.

percent hydrogen chloride by weight and that the specific gravity was 1.2); calculate the milliliters of concentrated potassium hydroxide solution required to contain the grams of potassium hydroxide taken (the concentration of this solution was $33\frac{1}{3}$ grams for 100 milliliters of solution).

From the stoichiometric relations, the grams of hydrogen chloride must be 146/112 times and the grams of manganese dioxide must be 87/112 times any position on the grams of potassium hydroxide scale. Because these ratios are fixed, these scales should be fixed permanently into position. Because the concentrations of the potassium hydroxide and hydrogen chloride solutions can vary these two scales should remain movable (variety can be added to the problem by assuming different concentrations for these two solutions). With the hair line set on 5 grams of potassium hydroxide we read 6.52 grams of hydrogen chloride, 3.88 grams of manganese dioxide, 15 milliliters of potassium hydroxide solution and 13.6 milliliters of concentrated hydrochloric acid. If desired, additional scales corresponding to grams of manganese chloride, chlorine, potassium chloride, etc. could be added.

In this work the author has found it quite convenient to assign a serial number to each member of the class. In this particular case $(0.05N+5)$ grams of potassium hydroxide was assigned to each student where N is the student's serial number. The number of grams of potassium hydroxide bears a straight line relation to N but it is not directly proportional to it. The N scale of Figure 2a then falls into class c of the special cases listed above. The N scale is based on the relationship

$$\text{gms. KOH} = 0.05N+5$$
$$\log \text{gms. KOH} = \log (0.05N+5)$$

and the logarithmic distances corresponding to each value of N are plotted along the N scale. The N scale should be easily removable so that it can be replaced by other scales. One moving tongue can, however, easily accommodate four N relationships, one each on the top and bottom edges of both the front and back of the tongue. In Figure 2a if the values of N be limited so that they do not exceed 100, this limited part of the scales can be expanded by a factor of three as shown in Figure 2b (the whole scale, if plotted would be 75 centimeters long instead of 25 centimeters). Only the N scale and the grams of potassium hydroxide scale are expanded in Figure 2b for purposes of illustration. The other scales could of course be added if desired. It should be noted that in order to gain an additional decimal point of accuracy, the scales would have to be expanded by a factor of ten. Such an expansion can easily become practical if the useful part of the scale is sufficiently limited.

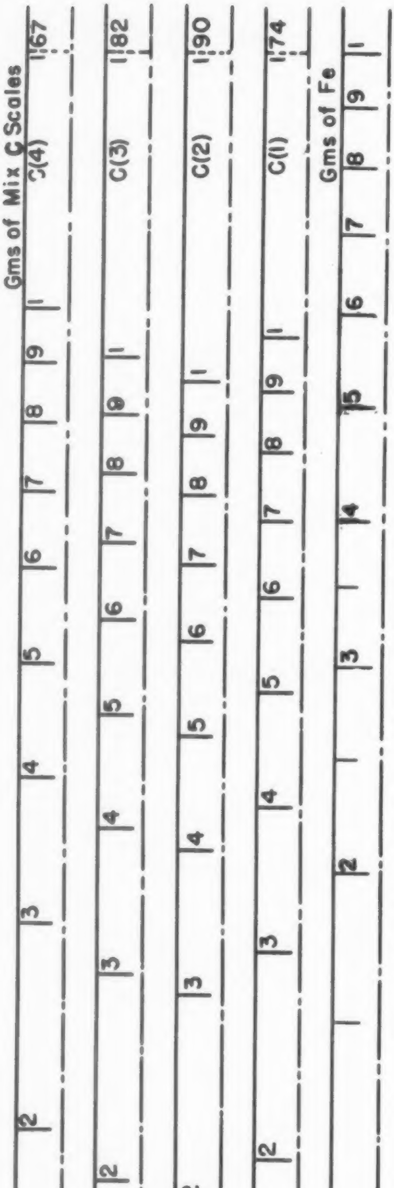

FIG. 3a. Showing a series of C scales, one of which is to be compared with the D scale.

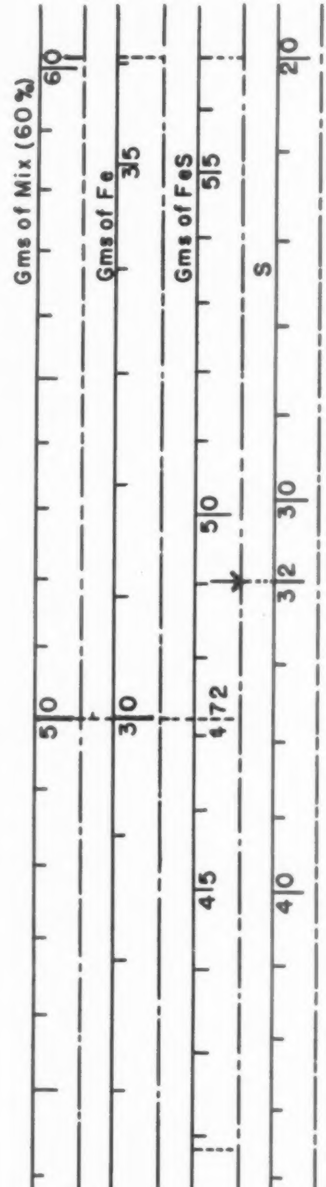

FIG. 3b. Showing a 10 fold expansion of a part of the D scale and a part of one of the C scales of Figure 3a. Here a moving grams of iron sulfide scale has been added so that any given reading on the D scale can be converted directly to atomic weight of sulfur on the S scale.

A combination of special features *a*, *b* and *c* described above will now be applied to the handling of a quantitative unknown suitable for beginning students. The problem is to determine the atomic weight of sulfur[7] from a mixture of pure iron powder with an excess but otherwise unknown amount of flowers of sulfur. The student is instructed to weigh out between 5 and 6 grams[8] of his unknown mixture, heat cautiously until reaction occurs and extract the excess sulfur from the crushed iron sulfide[9] cinder by means of carbon bisulfide. After this has been done the weight of the iron sulfide is determined. If now the student knew the grams of iron taken (the grams of iron in the amount of mixture taken and in the iron sulfide is the same) he could subtract it from the iron sulfide to get the grams of sulfur in the iron sulfide. This done the atomic weight of sulfur could be easily calculated from the relation

$$\frac{\text{gms. of } S}{\text{gms. of Fe}} = \frac{S}{55.85}$$

where 55.85 is the accepted atomic weight of iron and S is the experimentally determined atomic weight of sulfur. However, at this point the student knows only the grams of mixture taken and the grams of iron sulfide obtained. These two bits of data are now reported to the laboratory attendant who uses the special scales of Figure 3 to calculate the grams of iron taken and also to calculate the experimental value of S. The value for the grams of iron taken is given to the student and the calculated value for S is filed for future comparison with the student's calculations.[10]

In Figure 3a (see also Figure 4) a series of four unknown mixtures (of iron and sulfur) are represented. In scale one the percent of iron is 57.5, in scale two it is 52.5, in scale 3 it is 55 and in scale 4 it is 60. From the student's serial number N the laboratory attendant selects the appropriate scale, sets the hair line on the grams of mixture reported and reads off the grams of iron on the bottom scale. Suppose that a student has a mixture corresponding to scale 3 (55 percent iron) and that he reports 5.42 grams of mixture taken; the hair line

[8] The use of a sample as large as 5 to 6 grams makes it possible to use centigram balances and still obtain satisfactory results. Such balances are relatively inexpensive and require little time for the weighing operation. For large classes both of these advantages are quite important.

[9] The composition of the iron sulfide cinder is assumed to correspond to FeS. Experience has shown that this is very nearly true for the iron sulfide produced by the initial reaction.

[10] This procedure, which is made possible by the special scales of Figure 3, offers at least two important advantages. In the first place any form of dishonesty is rather effectively eliminated because the laboratory weighings are reported before the student can begin to calculate. In the second place the student can make an immediate comparison of his result with the accepted value for the atomic weight of sulfur.

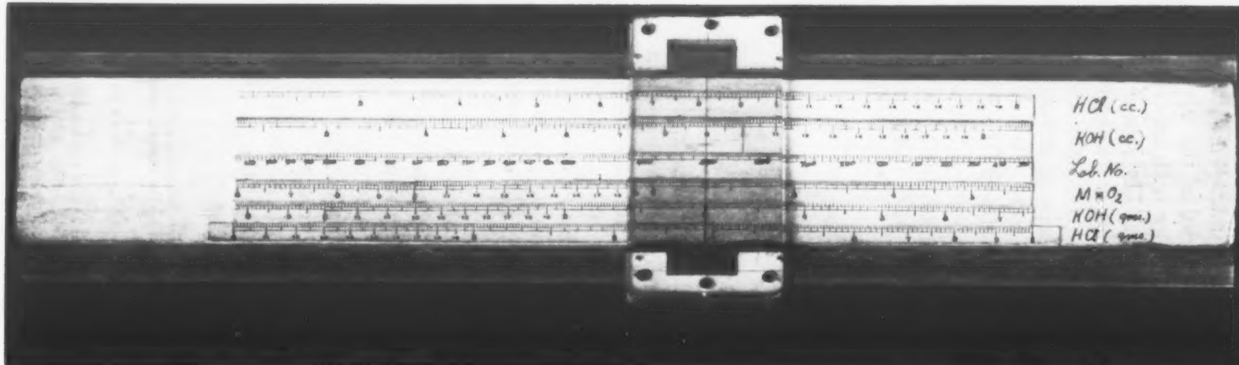

FIG. 4. Showing the construction of a special slide rule from an aluminum alloy sheet, veneer wood and printed logarithm scales.

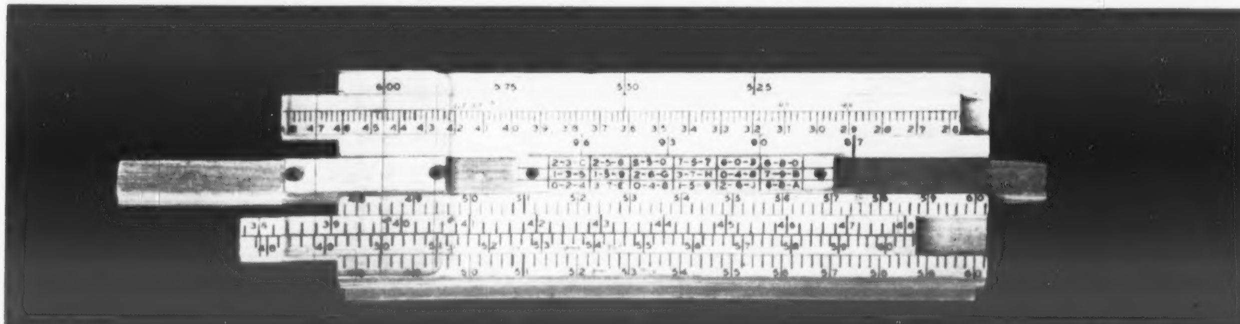

FIG. 5. Showing the construction of a special slide rule by mounting wooden slide rules on an aluminum alloy base. The logarithm scales are specially calculated and drawn on graph paper. Note especially the folded scales that add accuracy without adding length.

is set on 5.42 of scale 3 and 2.98 grams of iron is read off on the bottom scale.

If it be required that the grams of mixture taken be always between 5 and 6 grams this small part of the scale can be expanded by a factor of 10 (Figure 3b) and there will be a gain of one decimal place in accuracy which will now be about equal to the accuracy of a five place logarithm table. If now a movable grams of iron sulfide scale be mounted under the grams of iron scale, it will be possible to calculate the experimental value for the atomic weight of sulfur directly from the grams of iron and the grams of iron sulfide. The relationship used in the preparation of this new scale, the S scale, is

$$\frac{\text{gms. of Fe}}{\text{gms. of FeS}} = \frac{55.85}{55.85+S}$$

from which we have

$$\log \text{gms. Fe} - \log \text{gms. of FeS} = \log\left(\frac{55.85}{55.85+S}\right).$$

Successive values for S are substituted into the expression and log $(55.85/55+S)$ are obtained. The logarithmic distances are obtained by multiplying the logarithms by 250 centimeters in this case instead of 25 because of the 10 fold expansion of the scale. When plotted, these logarithmic distances are labeled with the corresponding values of S because it is these S values that we wish to read directly from the scale.

From Figure 3b it is to be seen that 5 grams of a 60 per cent mixture contins 3 grams of iron. Now 3 grams of iron will form $3(87.55/55.85) = 4.72$ grams of iron sulfide. If 4.72 on the grams of iron sulfide scale be placed under 3.0 on the grams of iron scale then the position of $S = 32$ can be indicated as shown by the arrow. The grams of iron sulfide scale must be a movable scale. If the stoichiometric quantity of iron sulfide be placed directly under the corresponding quantity of iron the arrow will always point to 32. If however, an experimental error is made and the amount of iron sulfide is not the stoichiometric quantity of iron sulfide, the arrow will point to some other value of S. Suppose that a large experimental error is made and that 4.18 grams of iron sulfide (instead of 4.72) is obtained for 3 grams of iron. When the iron sulfide scale is moved along until 4.18 is below 3 on the grams of iron scale, the arrow will be above 22. The low atomic weight for sulfur is obtained because of the error in the grams of iron sulfide.

Drawing and Construction

Figures 4 and 5 show two methods that have been used for the

construction of special slide rules. In Figure 4 a strip of thin veneer wood was fastened to a base of 1/16 inch aluminum alloy sheet by means of short wood screws. A sheet of good drawing board was then glued to the wood. The printed scales were purchased from a scientific supply house and were listed in the catalogue as scales for the preparation of cardboard slide rules. Another set of scales was mounted in a similar manner on the back of the rule and the plastic rider carries a hair line on both front and back.

In Figure 5 inexpensive wooden slide rules were fastened to an aluminum alloy base with screws and the original scales removed by means of a sander. These wooden slide rules are available in engineering supply stores and many department and variety stores in both 5 and 10 inch lengths. If some simple shop tools are available these rules can be conveniently arranged end to end or side by side in a variety of ways to meet almost any special need. The tongues can be joined by means of a splice joint if longer moving scales are required. If very many scales are to be placed side by side it might be better to place a guide at the bottom and use a draftsman's triangle instead of a rider.

The special logarithm scales were drawn on a good grade of millimeter graph paper. The markings on the paper should be checked for accuracy. In some cases the millimeter marks are slightly less or more than marked and sometimes they are not the same along the length as in the crosswise direction (this is especially true of paper sold from a roll). A good grade of graph paper is likely to be consistent in one direction at least and if this is taken into account the use of such paper in laying off these special scales is a great convenience.

The first step to be taken in calculating these special scales is to look up the logarithms of successive values of the quantity concerned. These logarithms are then multiplied by the length of the special scale and the products (logarithmic distances) plotted on the graph paper. A series of charts can be constructed for calculating these products or if the total scale length is an exact multiple of the ordinary scale it will be possible to use logarithm paper. Neither of these last mentioned methods will be found to be quite so accurate as the first method although they may be more rapid and convenient.

The author wishes to be the first to admit that this discussion is by no means complete. However, it is hoped that enough has been said to enable the reader to construct with pleasure and profit, special slide rules that can be made to serve whatever special needs he may have.

Heaven never helps the man who will not act.

—SOPHOCLES.

PUBLIC HEALTH APPLIED TO SCHOOL AND CLASSROOM HYGIENE

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The Project: To set up some criteria for a practical approach to improving school and classroom hygiene and communicable disease prevention from an interpretation of experimental data, research, and a survey of current literature.

Introduction: This paper is an effort to suggest solutions for some of the problems of hygiene and sanitation encountered in the classroom and school. In spite of phenomenal advances in preventive medicine in the last decade, school hygiene is still a challenge to educators everywhere. In the classroom, where students are in close contact with each other for a period of from one to five hours a day, communicable disease transmission is a constant threat.

In addition, the locker rooms, cafeterias, toilets, gymnasiums, and the assembly hall of the school are also possible environmental factors in tending to raise the incidence of infectious diseases if conditions are unsanitary.

The first cardinal principle of education is "Health," and health education should originate in the classroom, through the teacher of physical education, biology, and hygiene. Also important are the sanitary requirements in the classroom and school buildings. Teaching hygiene in unhygienic classrooms and buildings is as incongruous as teaching nature study entirely from textbooks. The classroom, particularly in winter, is a place where various communicable diseases may be spread. A knowledge of infections, their portal of entry, and mode of transmission, culminating in how to prevent them is of primary importance.

A. *Respiratory Infections*—such as the common cold, nasal catarrh, la grippe, virus influenza, bronchitis, virus or bacillary pneumonia, tuberculosis, so-called virus "X," and mixed viruses.
B. *Childhood Infections*—include whooping cough, measles, scarlet fever, diphtheria, mumps, epidemic cerebro-spinal Meningitis, and infantile paralysis.
C. *Contact Diseases*—may be spread in crowded schools by direct

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While the foregoing classroom communicable diseases seem formidable, it should be recalled that modern immunization techniques, antibiotics, and the sulfas have lowered their incidence considerably. Nevertheless, they are still a threat if unhygenic conditions prevail.

or indirect contact. Included are ring worm, athlete's foot, dhobie itch, pediculosis, syphilis, furunculosis (recurrent boils), crab lice, and the like.

D. *Insect Vectored Diseases*—include typhoid, dysentery, tuberculosis, diptheria, scarlet fever, and whooping cough, and possibly St. Louis Encephalitis. Mosquitoes in the south may vector malaria and dengue fevers, etc.

E. *Water and Food Born Infections*—include typhoid fever, dysentery, amebiasis, diphtheria, helminthiasis (tape or round-worm infections), milk born childhood diarrhea, etc.

Dust Bacteria: Dust harbors millions of bacteria, as many as twelve million bacteria per gram of dust in the classroom. Since many bacterial and mycotic invaders or pathogenic viruses can live for weeks in dust, it is obvious that the dusting, scrubbing, and sweeping operation by the janitor or custodial forces should be carried out correctly. Fluffy dusters should not be used in the classrooms as they stir up dust. Instead, the interior of the room and the furniture should be dusted with a dampened cloth, and the floors scrubbed with hot soapy water or liquid disinfectants. Sweeping should be performed with as little effort as possible so as not to cause the dust to rise rapidly, or to hang suspended in the air. Dust so suspended will finally settle on furniture, clothing and the like and be redistributed, throwing the bacteria back into the air again, where they may be inspired in breathing.

The racks underneath the blackboards should be kept clean and free from chalk dust by means of an oily or wet rag. Each day, preferably after school, the dusters should be cleaned free of chalk dust.

Respiratory Disease Incidence Related to Temperature and Humidity

The incidence of respiratory infections should be theoretically reduced if the teacher insists that students sneeze or cough into hygienic tissue, etc. Sneeze droplets can travel several feet explosively as a fine spray which may be loaded with pathogenic viruses and microbes, Sniffling, coughing, and sneezing students should be sent to the school nurse or physician for careful examination, or, at least, be isolated in the classroom where they can't spray their colleagues with possible droplet materials.The ventilation of the classroom assumes paramount hygienic importance. Temperatures above normal in a room tend to increase the number of air bacteria per cubic foot materially. Therefore, if the temperature goes much beyond the normal range of between 65–72 degrees Fahrenheit, the disease inciting bacteria multiply accordingly. In a hot, dry, or dusty class-

room with a temperature around 80 degrees and all the windows closed, the bacterial and viral contamination may run more than twice as high as that in rooms with normal temperatures, where adequate ventilation is maintained.

School Busses: Similar conditions particularly in the winter months may exist in school busses, when all windows are closed and the busses are over heated. Petri dishes exposed in crowded busses have repeatedly revealed very high colony counts of hemolytic streptococci, staphylococci, and pneumococci, etc., on blood agar plates testifying to the extent to which the air may be contaminated at times. Some ventilation should be provided even in the coldest weather to insure adequate air exchange.

Crowded Classrooms: In crowded classrooms with air temperature high an relative humidity low, the growth of infectious disease bacteria has an ideal incubation medium. Hygrodeik or wet and dry bulb thermometer readings should be taken in the classroom to check the relative humidity. If the humidity is low, then the opening of the windows, the placing of a few living plants around the room, or the evaporating of some water spilled over the floor surface in the roome will raise the humidity to safer levels.

A student going from a hot, dry, classroom of low humidity to winter cold out-doors and temperature around freezing will obviously be subject to violent atmospheric deviations which are quite apt to lower his resistance. Under such conditions a student is much more subject to upper respiratory, viral or bacillary infection, especially colds and influenza. Even in schools using the artificial ventilation or air conditioning systems, some natural ventilation is necessary at times. The windows might be opened for a few minutes every hour irrespective of the efficiency of the artificial ventilation system, so that a complete change of air is assured. Modern schools are placed in parks and open spaces in order to insure clean, uncontaminated air and as much of it as possible should be let in via the windows. Air polution or smog, is quite a problem in some urban areas, and some local health departments are setting up a Bureau of Environment Hygiene to cope with the situation.

The Stuffy Classroom: When students become restless or sleepy in the classroom, with the air hot or dry and oppressive, the student is inclined to become lazy or inattentive. Opening the windows for a few minutes is helpful and stimualting. The teacher may direct students to stand up for a few minutes before the open windows and take a few deep breaths. These deep breathing exercises and the change in the room air when the windows are open does much to dispel pupil lethargy and increase the span of attention.

Chalk Dust Sore Throat: Teachers using the blackboards exten-

sively have a tendency toward sore throat aggravated or caused by the inhalation of chalk dust, particularly during the winter sessions, when colds and upper respiratory infections are most prevalent. Microscopic examination of sputum from teachers suffering from sore throats has revealed the presence of chalk dust particles in the regular throat debris at times. Chalk particles irritate the first line of defense, namely the oral mucous membranes, so that the ever present mouth bacteria and viruses may become disease inciting.

Home Environment and Child Health: In schools located in poor socio-economic sections and downtown areas where children are apt to come from tenement houses and unhygienic homes, contact transmission of disease is always a possibility. The chief offender in this respect is the closed or round lavatory or toilet seat. Disease such as dhobie itch, ringworm, groin ringworm, crab lice, body lice, innocent gonorrhea, impetigo contagiosa, and by contact with insanitary toilet seats. The advantage of the open form of toilet seat is obvious in preventing the dissemination of these unpleasant skin conditions, and innocent venereal diseases. In addition, the regular, and frequent, thorough scrubbing of the toilets with strong soapy disinfectants such as lysol, creolin; or hypochlorous acid, etc. will do much to prevent the dissemination of diseases spread from this direct contact source.

Basement Hygiene and Skin Diseases: The gymnasium locker room, toilets and showers also serve as possible centers of infection for skin diseases, particularly athlete's foot, ringworm, and a ringworm-like disease of the groin. Dozens of bacterial plate exposures to the air of the gynmasium and locker rooms proved conclusivley that these places harbor more air and dust bacteria and fungi than any other part of the school building; therefore, particular cleanliness is necessary here. Fumigation, repainting, or disinfection of student lockers and locker rooms is advised particularly in old buildings. Students should be warned not to use other people's soap or towels. The basement toilets, wash basins, and urinals as indirect fomites of infection need very careful disinfectant treatment in order to keep down the aforementioned skin and other contact infections. Perspiration following exercise tends to increase the possibility of spreading mycotic skin diseases as was learned so forcefully in tropical campaigns in World War II. Schools in southern states have this problem to deal with today, and energetic sanitary measures are necessary to control these unpleasant mycotic, or fungus infections.

Athlete's foot is a common fungus disease which can originate in locker rooms and shower where students run around barefooted. Foot pans containing an antifungal agent may be tried as a preventive measure.

Droplet Infections: Cough or sneeze infections are among the most common found in the classroom. These include colds, coccal, and viral pneumonias, viral influenza, pertussis (whooping cough), measles, German measles, mumps, scarlet fever, diphtheria, tuberculosis, and menigitis, etc.

These droplet infections are spread as a cough, expectorant, or sneeze spray. Many avirulent viruses and microccoci are constant invaders usually as commensalists in the mouth, but many become virulent when the resistance is lowered. Therefore mouth hygiene assumes an important role in classroom hygiene. Dental care and dental health are essential, with thorough teeth and mouth cleansing an habitual "must."

Dental Hygiene: The most common dental disease among school children coming from schools in low socio-economic groups is "Vincent's angina" or "trench mouth." Oral hygiene and dental treatment are essential and periodic check ups by a visiting school dentist advisable.

Skin Health and Care: One physiological factor which has an adverse psychological effect on adolescents is acne, or excessive facial or skin blemishes. Students so affected may develop inferiority complexes and become introvertive. They often appear anti-social, despondent, and enter into a twilight world of compensatory day dreaming.

Facial blemishes are often coincident with initial shaving in adolescent boys. Shaving hygiene with light pressure on the razor and antiseptic after-shaving lotions help. Dietetic suggestions in cutting excess carbohydrate intake, particularly sugars in candy and soft drinks, can be presented by the interested science or hygiene teachers. Use of buttermilk, acidophilus or bulgarieus cultured milk, or yeast enriched foods may be of therapeutic benefit in some cases. Chronic, non-responsive cases should be referred to dermatologists, for treatment as this is a vital problem in the mental and physical health and well being of our youth.

Book Bacteria: Magazines, pamphlets, newsprint, papers, and books may harbor bacterial, mycotic and viral organisms in the dirt and grime found on the pages. Old school books could be opened up and put out in the sunlight for several hours where practicable. Books used by sick children should not be handed out to other students immediately, for most pathogens soon lose their virulence or die out entirely if kept away from the body tissues for some time. School books which are dilapidated, out of date, and filthy with grime should be destroyed, or reconditioned, sunned, aired, or chemically treated.

Destroy books coming from quarantined homes, or at least hold

them for several months before redistribution. Books used in infectious disease wards of hospitals should not be redistributed.

Books used by people suffering from colds, sore throats, influenza, measles, scarlet fever, whooping cough, diphtheria, meningitis, polio, virus or bacillary pneumonia, tuberculosis, and books read while convalescing from these diseases should be stored for a safe period of time before redistribution, or preservatives sprayed on them. Books used by pulmonary tuberculary patients, particularly those suffering from phthisis, or other acute T. B. infections, should under no circumstances, be used by anybody else.

If epidemics of childhood diseases occur in schools, books from sick children should not be redistributed until several weeks have elapsed, and then preferably only after exposure to the sun for several hours.

The U. S. Public Health Service advises that books read by patients exposed to infection should be handled with extreme care. The books so contaminated should be disinfected by dry heat, formaldehyde gas, or sprinkled with a few drops of formalin on each page and placed in a closed receptacle for at least 24 hours. Unbound books or pamphlets may be disinfected by live steam, or destroyed.

The teacher and class health: The teacher's role in school health is the first line of defense for her observations may motivate medical and dental assistance in time to prevent infections from spreading in her classroom. Teachers should be on the lookout for:

1. *Sniffles.*—Possible forerunner of colds, influenza, meningitis, rhinitis, pneumonia, bronchitis, poliomyelitis, infected sinuses, diphtheria, hay fever, etc.
2. *Rash.*—Scarlet fever, measles, chicken pox, and in rural areas typhoid and erysipelas.
3. *Skin Lesions, Local.*—Acne vularis, impetigo, contagiosa, ring worm, athlete's foot. Gym teachers might observe these.
4. *Swellings (Glands).*—An indication of an infection near the gland; mumps, swollen salivary glands.
5. *Color.*—A. Red, flushed, hot, indicates a fever, usually a sign of some infection.
   B. Local heat and redness or tenderness, abscess, boils, sprain, appendicitis.
   C. Color pale, chronic fatigue, malnutritions, avitaminosis, rheumatic fever.
6. *Difficult or Labored Breathing.*—Adenoids, polyps, tonsilitis, tuberculosis, bronchitis, or pneumonia.
7. *Discharges.*—Ear, mastoiditis, otitis, (ear infection), rheumatic fever, (nose and throat discharges).
8. *Nausea or Vomiting.*—Food poisoning, gastritis, (upset stomach), dyspepsia.

General symptoms suggesting some acute communicable disease are: nausea or vomiting; headache, earache, or aching in back or legs; a chill or chilliness; fever, flushed face, lassitude, malaise; sore or

scratchy throat; watery nasal discharge; tight, dry cough, sneezing; skin rash or local redness; swollen glands.

Suggested School Immunization Program

The program of preventive immunization which might be made available to school children either through their family physician, school doctor, or nurse included: compulsory—Small Pox Vaccination; strongly advised, Diphtheria, Toxoid, for immunization against Lockjaw; Sauer vaccination against whoop cough; Paratyphoid and Typhoid vaccination for students in rural areas; Influenza A, B, and C viral vaccine or polyvalent influenza vaccine. (Has been very successful in industry and the armed forces, and might be extended to include volunteer school population); Salk viral immunization agaist poliomyelitis on a voluntary basis.

Summary and Conclusions

The paper suggests measures for lowering the incidence of communicable disease in schools, by enforcing logical control measures and sanitary codes. The prevention of accidents and emergencies is stressed particularly in connection with competitive sports. All teachers should be trained in first aid to relieve the school nurse for health appraisals and routine examinations. Teachers, also are in the best position to recognize symptoms and signs of abnormal conditions in their pupils, because school doctors' and nurses' services are usually irregular and infrequent. Some training is therefore highly desirable in teacher hygiene training programs.

Interest in the nutritional or dietetic aspects are an integral part of any school health problems, with the cafeteria and school lunches as factors in child health.

Handicapped children should be indentified, and their cases studied for remedial measures. Health education is a *must*, throughout a pupil's school career. In the higher grades, the science teacher should emphasize the human relations aspects of physiology, bacteriology, public health, parasitology, and epidemiology as classroom problems for discussion.

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SOME ASPECTS OF PRESENTING A UNIT ON THE EARTH AND THE SUN TO CHILDREN OF THE PRIMARY GRADES

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The study of science should result in the child being able to "do" something better, and becoming increasingly independent in the "doing." Isn't this true of the study of reading, writing, spelling, and arithmetic? Emphasizing "content" and the "identification of things" does not bring about the desired results. Attention must be given to scientific method.

What should the child be able to do better for having had "doing" experiences in the following areas of scientific method: (1) careful observation, (2) accurate reporting, (3) examining "cause and effect" relationships, and (4) examining existing similarities and differences? With guidance, he should grow in his ability to: (1) explain "cause and effect" in terms of scientific principles, (2) determine which facts are pertinent to a situation and which are not, (3) determine to which areas scientific explanations belong, (4) determine when one has enough information to form a conclusion and when one must defer judgment because of lack of sufficient information, and (5) obtain information through experiment rather than by accepting superstition. In other words, the child should be able to "do" better thinking and become increasingly independent in this thinking.

Initially, it is necessary for the beginning scientist to have some understanding of the relationship of himself, in his immediate environment, to the Universe as a whole. And, while it is recognized and expected that the concepts and understandings in this area can be developed only generally, nevertheless, a beginning can be made. Some suggestions for presenting, in "doing" situations, some of the more meaningful of these basic concepts are offered here for consideration.

"What do we know about this world in which we live?" Let the children tell *you* what they know or what they've learned from examining the globe and the science books which you've carefully selected and placed on the science table. They'll probably tell you, among other things, that the earth is round, that it moves, and that it is very big. Add to this knowledge: Demonstrate that the earth is so big that we don't even feel it move when it spins around (like this) while traveling around the sun (like this).

Plan a trip outdoors to discover of what our earth is composed. Take pad and pencil; the children may want to sketch what they see. (On-the-spot notes or sketches encourages careful observation and insures more accurate reporting.) Once back in the classroom, discuss what was seen and how these things are important to us. Perhaps the children will suggest a mural as a way of depicting how man uses the air, how he uses the land, and how he uses the water. An experience such as this gives added meaning to the concepts being developed—ties them together.

"Does the earth provide for all our needs?" Let the children discuss this question and defend their answers. With the children, plan and carry out an experiment that will answer the question: Do green plants need sunshine? When this question has been answered, discuss: What would happen to us if there were no plants? Let the children think it through. Someone will tell you that we'd still have meat, milk, cheese, and ice cream. Help the children to think through that the animals eat plant food in order to produce these foods. And all life depends upon the sun! (The thinking through of this cause and effect concept gives added meaning to the relationship of the child to the Universe.)

A question that usually arises is: If the sun is larger than the earth, why does it look smaller? This can be demonstrated. Take two basketballs out onto the playground. Keep one ball near the children, and move the other one away from them. Have the children compare the apparent sizes of the two balls, and they will discover that distance makes the difference, (another cause and effect relationship).

In a darkened room, it is easy to demonstrate how the earth's rotation causes night and day. While one child stands on a chair with a flashlight to represent the sun, and another child slowly turns the globe around, let small groups of children take turns following the globe around. When our part of the world goes into darkness, what happens to the other part of the world? Using a small, round mirror, the teacher can also demonstrate the reflection of the moon on the darkened side of the earth.

The trend such a unit will take is hard to determine. Perhaps the children will be interested in the riches inside the earth, and will

want to collect and examine minerals. Or, perhaps they will develop an interest in the plants and animals of the world—which ones live where it's hot? Which where it's cold? Which in the water? Which in the air? Which on land? Which underground? In any event, emphasize the scientific method in your planning; and, once your material is in its logical order, present it in such a way that the child can organize it to make meaning out of it for himself!

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MATHEMATICS INSTITUTE AT WILLIAMS COLLEGE

The Eighth Annual Institute for Teachers and Professors of Mathematics, sponsored by the Association of Teachers of Mathematics in New England, will be held at Williams College, Willismstown, Massachusetts, August 16–23, 1956. Mrs. Frances L. Allen of the Newton (Mass.) High School is General Chairman.

The program consists of morning and evening lectures and three periods daily for discussion groups (four choices each period) with topics of interest to teachers from the seventh grade up. Social hours and other recreational activities are also planned.

Some of the topics to be discussed are "Enrichment of the Teaching of Junior High School Mathematics" (Veryl Schult, leader), "How to Integrate Algebra, Geometry, and Trigonometry with Conventional Textbooks" (Jackson B. Adkins, leader), "Creative Imagination in the Teaching of Mathematics" (Ernest E. Ranucci, leader), and "Number Systems" (Albert A. Bennett, leader). In addition to the junior and senior high school laboratories, Professor Edwin A. Hoadley will be back with both beginners' and advanced courses in "Geometry Applied to Artistic Design." Other group leaders are M. Philbrick Bridgess, Bruce E. Meserve, William R. Ransom, Ambrose R. Clarke, Alice Hach, and Lauren Woodby.

Cost: \$12.50 registration fee for the entire Institute; room in dormitory, \$2 a night; meals, \$4 a day.

Williamstown is beautifully situated in the Berkshire Hills of western Massachusetts, one of New England's fine recreational areas. Combine a vacation trip with this week of professional growth!

For a complete program and other information, please write to the Publicity Chairman, Miss Barabara B. Betts, 138 Norfolk Avenue, Swampscott, Massachusetts.

PROBLEM DEPARTMENT

CONDUCTED BY MARGARET F. WILLERDING
Harris Teachers College, St. Louis, Missouri

This department aims to provide problems of varying degrees of difficulty which will interest anyone engaged in the study of mathematics.

All readers are invited to propose problems and to solve problems here proposed. Drawings to illustrate the problems should be well done in India ink. Problems and solutions will be credited to their authors. Each solution or proposed problem sent the Editor should have the author's name introducing the problem or solution *as on the following pages.*

The editor of the Department desires to serve his readers by making it interesting and helpful to them. Address suggestions and problems to Margaret F. Willerding, Harris Teachers College, St. Louis, Missouri.

SOLUTIONS AND PROBLEMS

Note. Persons sending in solutions and submitting problems for solutions should observe the following instructions.

1. Solutions should be in typed form, double spaced.

2. Drawings in India ink should be on a separate page from the solution.

3. Give the solution to the problem which you propose if you have one and also the source and any known references to it.

4. In general when several solutions are correct, the one submitted in the best form will be used.

LATE SOLUTIONS

2485, 2486, 2488, 2489, 2491, 2492, 2494, 2495, 2496. *C. W. Trigg, Los Angeles, Calif.*

2491, 2496. *George Senge, Los Angeles, Calif.*

2491, 2492, 2493, 2495, 2496. *W. R. Talbot, Jefferson City Mo.*

2496. *Mart Michell, Plainfield, Ill.*

2496. *Raleigh Ellisin, Petaluma, Calif.*

2496. *Richard H. Bates, Milford, N. Y.*

2494. *Gerald E. Doeden, Valparaiso, Ind.*

2497. *Proposed by Brother Felix John, Philadelphia, Pa.*

A number of $2n$ digits is divisible by 11. How many permutations of this number are also divisible by 11?

Solution by C. W. Trigg, Los Angeles City College

A standard test for divisibility by 11 involves the difference of the two sums of the alternate digits of an integer. If this difference is divisible by 11, then the integer is divisible by 11 also. In an integer of $2n$ digits, the digits of one set of alternate digits may be permuted in $n!$ ways, as may the digits of the other set also. Since permutation does not change the sum of the set, it follows that if the integer is divisible by 11, then $(n!)^2$ of the permutations of its digits also are divisible by 11. However, these permutations may not all be distinct due to repetition of digits, nor may a permutation in which one or more zeros appear on the left properly be considered a $2n$-digit number.

It is doubtful whether a general answer to the problem is possible, for $(n!)^2$

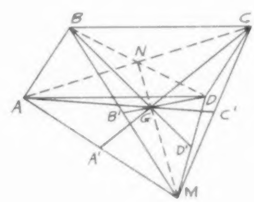
may not be the totality of permutations divisible by 11. A specific case in point is provided by the two permutations 1415162738 and 1112436578. In the first one, the difference of the sums is 22; in the second one, 0. Both of these differences are divisible by 11. Therefore, there are $2\,(5!)^2$ of the permutations of this set of digits which are divisible by 11.

Solutions were also offered by Richard H. Bates, Milford, N. Y.; and Herbert Wolf, Chicago, Ill.

2498. *Proposed by Nathan Altshiller-Court, University of Oklahoma.*

AB, CD and AD, BC are the two pairs of opposite sides of a parallelogram, and A', B', C', D' are the midpoints of the lines joining the vertices, A, B, C, D, to a given point M. Show that the four lines AC', BD', CA', DB' intersect each other in the same point.

Solution by C. W. Trigg, Los Angeles City College



Method I. Draw the diagonal AC and BD which bisect each other at N. In the triangle BDM, the medians BD', DB' and MN intersect at G, such that $MG=\frac{2}{3}$ MN. In triangle ACM, the medians AC', CA', and MN intersect at a point on MN which is $\frac{2}{3}$ MN from M, and therefore is G. Hence the proposition.

The proposition generalizes immediately to a pyramid with a parallelogram base. Also, the joins will be concurrent if $MA':A'A::MB':B'B::MC':C'C::MD':D'D$.

Method II. Using oblique coordinates, with the vertices of the parallelogram at $A(0, 0)$, $B(0, 2b)$, $C(2a, 2b)$, $D(2a, 0)$, and the arbitrary point $M(2m, 2n)$, we have $A'(m, n)$, $B'(m, n+b)$, $C'(m+a, n+b)$, $D'(m+a, n)$ and

$$AC':(m+a)y=(n+b)x$$
$$BD':(m+a)y=(n-2b)x+2(bm+ab)$$
$$CA':(m-2a)y=(n-2b)x+2(bm-an)$$
$$DB':(m-2a)y=(n+b)x-2(an+ab).$$

Now the intersection of every pair of these lines is

$$G[2(a+m)/3,\ 2(b+n)/3].$$

Solutions were also offered by Richard H. Bates, Milford, N. Y.; A. R. Haynes, Tacoma, Wash.; Mabel Ogden, Yarmouth, Arcadia, Canada; Walter R. Warne, St. Petersburg, Fla.; and the proposer.

2499. *Proposed by O. F. McCrary, Raleigh, N. C.*

Three boys having 10, 30, and 50 applies respectively visit a city and sell them at the same rate, and receive the same amount for them. How much do they receive for the applies, and at what rate do they sell them?

Solution by C. W. Trigg, Los Angeles City College

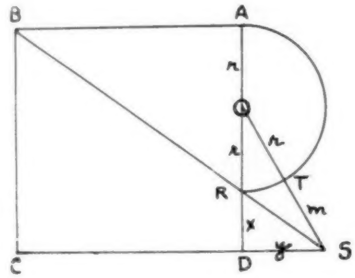
If each boy receives the same amount of money, then it must be intended that each boy sells his own apples at a uniform price. Presumably, it is also intended

that the various prices be the smallest prices in cents which will meet the other conditions. Under these restrictions, let the respective prices by x, y, z. Then $P=10x=30y=50z$, so $P=150$ cents, and the various rates are 15, 5 and 3 cents per apple, respectively. In general, $P=150k$, $x=15k$, $y=5k$, and $z=3k$.

2500. *Proposed by Leon Bankoff, Los Angeles, Calif.*

A point R is chosen on side AD of a square $ABCD$ and a circle O is described on diameter AR. Extend BR and CD to meet in S, and draw the line segment OS cutting O in T. Show that $ST=SD$.

Solution by Charles H. Butler, Kalamazoo, Michigan



Using for convenience the notation shown in the accompanying diagram, we note that in right triangle SOD,

$$(r+m)^2=(r+x)^2+y^2$$

or

$$r^2+2rm+m^2=r^2+2rx+x^2+y^2 \tag{1}$$

In the similar triangles RDS and RAB we have

$$\frac{x}{y}=\frac{2r}{2r+x},$$

whence $2rx+x^2=2ry$. Substituting this in (1) we have

$$r^2+2rm+m^2=r^2+2ry+y^2, \quad \text{or} \quad (r+m)^2-(r+y)^2=0.$$

Upon factoring, this yields the solutions $m=\pm y$.

Rejecting the negative solution (since neither m nor y can be negative) it follows that $m=y$ or $ST=SD$.

Solutions were also offered by Richard H. Bates, Milford, N. Y.; S. Robert Collins, Tampa, Fla.; A. R. Haynes, Tacoma, Wash.; Fannie Larkin, Waco, Texas; C. W. Trigg, Los Angeles, Calif.; Coe S. Warne, Richmond, Va.; Anna Wilson, Levis Junction, Canada; Herbert Wolf, Chicago, Ill.; and the proposer.

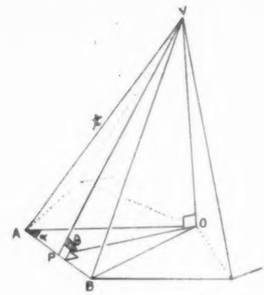
2501. *Proposed by Charles H. Butler, Kalamazoo, Michigan.*

Given, a right regular pyramid of n faces, with lateral edges t units long and base edges b units long. Find an expression in terms of n, t, and b for the common measure of the dihedral angles at the base.

Solution by the proposer

Using the lettering on the accompanying diagram with V the vertex of the pyramid, O the foot of the perpendicular from V to the base polygon, and P the midpoint of the base edge AB, we note that $AB=b$, $OP\perp OV$, $OP\perp AB$, and $VP\perp AB$. To simplify notation, let $AP=a=\frac{1}{2}b$, $\angle OAP=\alpha$, and $\angle OPV=\theta$. We

seek an expression for θ since it is the plane angle of the dihedral angle in question.



Now clearly

$$\theta = \arccos \frac{OP}{VP}.$$

In

$$\triangle APO,\ \alpha = \frac{1}{2}\ \frac{(n-2)180^\circ}{n} = \frac{(n-2)90^\circ}{n}.$$

Therefore

$$OP = a \tan \alpha = a \tan \frac{(n-2)90^\circ}{n}.$$

In

$$\triangle APV,\ VP = \sqrt{l^2 - a^2}.$$

Therefore

$$\theta = \arccos \frac{OP}{VP} = \arccos \left(\frac{a \tan \dfrac{(n-2)90^\circ}{n}}{\sqrt{l^2 - a^2}} \right)$$

Substituting $\frac{1}{2}b$ for a, this reduces to

$$\theta = \arccos \left(\frac{b \tan \dfrac{(n-2)90^\circ}{n}}{\sqrt{4l^2 - b^2}} \right)$$

A solution was also offered by Richard H. Bates, Milford, N. Y.; and C. W. Trigg, Los Angeles, Calif.

2502. *Submitted by A. R. Haynes, Tacoma, Wash.*

If the sides of $\triangle ABC$ are $a_ix + b_iy + c_i = 0$ $(i = 1, 2, 3)$, then show that

$$\text{Area} = 1/2[a_1b_2c_3]^2/[a_1b_2][a_1b_3][a_2b_3]$$

where the determinants are represented by enclosing their principal terms in brackets.

Solution by Herbert Wolf, Chicago, Ill.

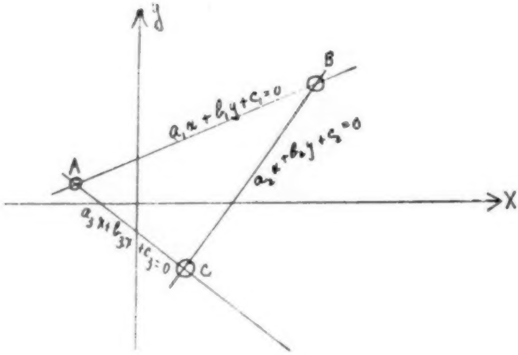
Part 1. Calculating coordinates of A, B, & C.

$$a_1x + b_1y + c_1 = 0$$
$$a_2x + b_2y + c_2 = 0$$
$$a_3x + b_3y + c_3 = 0$$

$$\text{A:}\quad x=\frac{\begin{vmatrix} b_1 & c_1 \\ b_3 & c_3 \end{vmatrix}}{\begin{vmatrix} a_1 & b_1 \\ a_3 & b_3 \end{vmatrix}} \qquad y=-\frac{\begin{vmatrix} a_1 & c_1 \\ a_3 & c_3 \end{vmatrix}}{\begin{vmatrix} a_1 & b_1 \\ a_3 & b_3 \end{vmatrix}}$$

$$\text{B:}\quad x=\frac{\begin{vmatrix} b_1 & c_1 \\ b_2 & c_2 \end{vmatrix}}{\begin{vmatrix} a_1 & b_1 \\ a_2 & b_2 \end{vmatrix}} \qquad y=-\frac{\begin{vmatrix} a_1 & c_1 \\ a_2 & c_2 \end{vmatrix}}{\begin{vmatrix} a_1 & b_1 \\ a_2 & b_2 \end{vmatrix}}$$

$$\text{C:}\quad x=\frac{\begin{vmatrix} b_2 & c_2 \\ b_3 & c_3 \end{vmatrix}}{\begin{vmatrix} a_2 & b_2 \\ a_3 & b_3 \end{vmatrix}} \qquad y=-\frac{\begin{vmatrix} a_2 & c_2 \\ a_3 & c_3 \end{vmatrix}}{\begin{vmatrix} a_2 & b_2 \\ a_3 & b_3 \end{vmatrix}}$$



Part 2. Calculating area.
The area of any

$$\triangle=\frac{1}{2}\begin{vmatrix} x_1 & y_1 & 1 \\ x_2 & y_2 & 1 \\ x_3 & y_3 & 1 \end{vmatrix}$$

where the vertices are taken in counter-clockwise order.

$$A=\frac{1}{2}\begin{vmatrix} \dfrac{\begin{vmatrix} b_1 & c_1 \\ b_3 & c_3 \end{vmatrix}}{\begin{vmatrix} a_1 & b_1 \\ a_3 & b_3 \end{vmatrix}} & -\dfrac{\begin{vmatrix} a_1 & c_1 \\ a_3 & c_3 \end{vmatrix}}{\begin{vmatrix} a_1 & b_1 \\ a_3 & b_3 \end{vmatrix}} & 1 \\ \dfrac{\begin{vmatrix} b_2 & c_2 \\ b_3 & c_3 \end{vmatrix}}{\begin{vmatrix} a_2 & b_2 \\ a_3 & b_3 \end{vmatrix}} & -\dfrac{\begin{vmatrix} a_2 & c_2 \\ a_3 & c_3 \end{vmatrix}}{\begin{vmatrix} a_2 & b_2 \\ a_3 & b_3 \end{vmatrix}} & 1 \\ \dfrac{\begin{vmatrix} b_1 & c_1 \\ b_1 & c_2 \end{vmatrix}}{\begin{vmatrix} a_1 & b_1 \\ a_2 & b_2 \end{vmatrix}} & -\dfrac{\begin{vmatrix} a_1 & c_1 \\ a_2 & c_2 \end{vmatrix}}{\begin{vmatrix} a_1 & b_1 \\ a_2 & b_2 \end{vmatrix}} & 1 \end{vmatrix} = -\frac{1}{2\begin{vmatrix} a_1 & b_1 \\ a_3 & b_3 \end{vmatrix}\begin{vmatrix} a_2 & b_2 \\ a_3 & b_3 \end{vmatrix}\begin{vmatrix} a_1 & b_1 \\ a_2 & b_2 \end{vmatrix}}\begin{vmatrix} \begin{vmatrix} b_1 & c_1 \\ b_3 & c_3 \end{vmatrix} & \begin{vmatrix} a_1 & c_1 \\ a_3 & c_3 \end{vmatrix} & \begin{vmatrix} a_1 & b_1 \\ a_3 & b_3 \end{vmatrix} \\ \begin{vmatrix} b_2 & c_2 \\ b_3 & c_3 \end{vmatrix} & \begin{vmatrix} a_2 & c_2 \\ a_3 & c_3 \end{vmatrix} & \begin{vmatrix} a_2 & b_2 \\ a_3 & b_3 \end{vmatrix} \\ \begin{vmatrix} b_1 & c_1 \\ b_2 & c_2 \end{vmatrix} & \begin{vmatrix} a_1 & c_1 \\ a_2 & c_2 \end{vmatrix} & \begin{vmatrix} a_1 & b_1 \\ a_2 & b_2 \end{vmatrix} \end{vmatrix}$$

$$=\frac{1}{2\begin{vmatrix} a_1 & b_1 \\ a_3 & b_3 \end{vmatrix}\begin{vmatrix} a_2 & b_2 \\ a_3 & b_3 \end{vmatrix}\begin{vmatrix} a_1 & b_1 \\ a_2 & b_2 \end{vmatrix}}\begin{vmatrix} \begin{vmatrix} a_1 & c_1 \\ a_3 & c_3 \end{vmatrix} & \begin{vmatrix} b_1 & c_1 \\ b_3 & c_3 \end{vmatrix} & \begin{vmatrix} a_1 & b_1 \\ a_3 & b_3 \end{vmatrix} \\ \begin{vmatrix} a_2 & c_2 \\ a_3 & c_3 \end{vmatrix} & \begin{vmatrix} b_2 & c_2 \\ b_3 & c_3 \end{vmatrix} & \begin{vmatrix} a_2 & b_2 \\ a_3 & b_3 \end{vmatrix} \\ \begin{vmatrix} a_1 & c_1 \\ a_2 & c_2 \end{vmatrix} & \begin{vmatrix} b_1 & c_1 \\ b_2 & c_2 \end{vmatrix} & \begin{vmatrix} a_1 & b_1 \\ a_2 & b_2 \end{vmatrix} \end{vmatrix}$$

$$=\frac{1}{2}\,[a_1\,b_2\,c_3]^2/[a_1\,b_2][a_1\,b_3][a_2\,b_3]$$

A solution was also offered by C. W. Trigg, Los Angeles, Calif., and the proposer.

STUDENT HONOR ROLL

The Editor will be very happy to make special mention of classes, clubs, or individual students who offer solutions to problems submitted in this department. Teachers are urged to report to the Editor such solutions.

Editor's Note: For a time each student contributor will receive a copy of the magazine in which his name appears.

PROBLEMS FOR SOLUTION

2421. *Proposed by Richard H. Bates, Milford, N. Y.*

In a parallelogram of sides a and b and included angle θ, a diagonal is drawn. In each triangle thus formed a circle is inscribed. Derive a formula for the line of centers of these circles in terms of a, b and θ.

2422. *Proposed by A. B. Lonski, Los Angeles, Calif.*

A horse is tethered on the circumference of a circular field, the area of which is one acre. Determine the length of the rope so that the horse may graze on half of the circular field.

2423. *Proposed by F. A. Lee, Jr., Lynchburg, Va.*

A room is in the shape of a rectangular parallelepiped, a units long, with ends squares of length b. A point A is on one end one unit down from the ceiling and half-way across; a corresponding point B is on the other end one unit from the floor and half-way across.

One pathway from A to B is straight down the wall from A to the floor, straight across and up to B. This distance is $a+b$.

Find rational values of a and b for which there are other pathways from A to B equal to $a+b$. These pathways may be measured along any or all of the following: ceiling, sides, ends, floor.

2424. *Proposed by Joseph Kennedy, Madison, Wis.*

$$\begin{array}{ccccccccccccc}
 & & & & & & 1 & & & & & & \\
 & & & & & 1 & & 1 & & & & & \\
 & & & & 1 & & 2 & & 1 & & & & \\
 & & & 1 & & 3 & & 3 & & 1 & & & \\
 & & 1 & & 4 & & 6 & & 4 & & 1 & & \\
 & 1 & & 5 & & 10 & & 10 & & 5 & & 1 & \\
1 & & 6 & & 15 & & 20 & & 15 & & 6 & & 1
\end{array}$$

etc.

It is observed that the totals which may be made by three dice may be made in the following number of ways:

Total	3	4	5	6	7	8	9	10	11	12	13	14	15	16
No. of Ways	1	3	6	10	15	21	28	36	36	28	21	15	10	6

These numbers occur in the diagonal of the Pascal Triangle beginning at one end of the third row.

It is further observed that the diagonal beginning at the end of the nth row seems to give the number for n dice. Why does this happen?

2425. *Proposed by J. W. Lindsey: Amarillo, Texas.*

Solve

$$\sqrt[3]{e^{2-x}}\sqrt[4]{e^{4-x}}\sqrt[5]{e^{5x-1}}=1$$

2426. *Proposed by Charles H. Butler, Kalamazoo, Mich.*

Prove the existence of a triangle ABC in which $m_c<a<b$, with m_c, a, b in arithmetic progression, and give formulas for a and b in terms of m_c and the third side c $(=AB)$ of the triangle.

BOOKS AND PAMPHLETS RECEIVED

General Chemistry for Colleges, Fifth Edition, by B. Smith Hopkins, *Late Professor of Inorganic Chemistry, University of Illinois*, and John C. Bailar, Jr., *Professor of Chemistry, University of Illinois*. Cloth. Pages x+701. 16×23.5 cm. 1956. D. C. Heath and Company, 285 Columbus Avenue, Boston 16, Mass. Price $6.00.

The Preservation of Natural History Specimens, Edited and Compiled by Reginald Wagstaffe, and J. Havelock Fidler, M.A., Ph.D. Volume One, Invertebrates. Cloth. Pages xiii+205. 18.5×25 cm. 1955. Philosophical Library, Inc., 15 East 40th Street, New York 16, N. Y. Price $10.00.

Through the Mathescope, by C. Stanley Ogilvy, Ph.D., *Assistant Professor of Mathematics at Hamilton College*. Cloth. Pages vii+162. 13.5×20.5 cm. 1956. Oxford University Press, 114 Fifth Avenue, New York 11, N. Y. Price $4.00.

Mathematics Review Exercises, Third Edition, by David P. Smith, Jr. and Leslie T. Fagan, *Lawrenceville School, Lawrenceville, New Jersey*. Cloth. Pages vi+346. 15×23.5 cm. 1956. Ginn and Company, Statler Building, Boston 17, Mass. Price $3.00.

Dictionary of Arts and Crafts, by John L. Stoutenburgh, Jr., *Department of Public Instruction, American Museum of Natural History, New York*. Cloth. Pages vii+259. 13.5×21 cm. 1956. Philosophical Library, Inc., 15 East 40th Street, New York 16, N. Y. Price $6.00.

An Introduction to Mathematics: A Historical Development, by Lee Emerson Boyer, *Millersville State Teachers College, Millersville, Pennsylvania*. Revised Edition. Cloth. Pages xvi+528. 13.5×21 cm. 1955. Henry Holt and Company, 383 Madison Avenue, New York 17, N. Y. Price $5.25.

Using Mathematics, 7. by Kenneth B. Henderson, *Professor of Mathematics Education, University of Illinois*, and Robert E. Pingry, *Supervisor of Student Teaching in Mathematics, University of Illinois*. Cloth. Pages xii+436. 14×21.5 cm. 1956. McGraw-Hill Book Company, Inc., 330 West 42nd Street, New York 36, N. Y. Price $2.96.

TODAY'S GEOMETRY, Fourth Edition, by Lee R. Spiller, *Mathematician, Douglas Aircraft Company, Inc., Formerly Mathematics Instructor, Hillhouse High School, New Haven, Connecticut;* Franklin Frey, *Head, Mathematics Department, Cass Technical High School;* and David Reichgott. Cloth. 331 pages. 14.5×23 cm. 1955. Prentice-Hall, Inc., 70 Fifth Avenue, New York 11, N. Y. Price $3.28.

PLANE TRIGONOMETRY, by Abraham Spitzbart and Ross H. Bardell, *University of Wisconsin.* Cloth. Pages viii+205. 14×21.5 cm. 1955. Addison-Wesley Publishing Company, Inc., Cambridge 42, Mass. Price $3.75.

ARITHMETIC WE NEED, Grade 8, by Guy T. Buswell, *University of California, Berkeley;* William A. Brownell, *University of California, Berkeley;* and Irene Sauble, *Detroit Public Schools, Michigan.* Cloth. 336 pages. 14.5×22.5 cm. 1956. Ginn and Company, Statler Building, Boston 17, Mass. Price $2.08.

GEOMETRY OF FOUR DIMENSIONS, by Henry Parker Manning. Paper. Pages ix+348. 13×20.5 cm. Dover Publications, Inc., 920 Broadway, New York 10, N. Y. Price $1.95.

THE ANALYTICAL THEORY OF HEAT, by Joseph Fourier. Translated with Notes by Alexander Freeman, M.A., *Fellow of St. John's College, Cambridge.* Paper. Pages xxiii+466. 12.5×20.5 cm. 1955. Dover Publications, Inc., 920 Broadway, New York 10, N. Y. Price $1.95.

CALCULUS, DIFFERENTIAL AND INTEGRAL WITH PROBLEMS AND SOLUTIONS, by G. M. Petersen and R. F. Graesser, *Head Department of Mathematics, University of Arizona.* Paper. Pages x+321. 12.5×20.5 cm. 1956. Littlefield, Adams and Company, 128 Oliver Street, Paterwon 1, N. J. Price $1.75.

NELLIE LANDBLOM'S COPYBOOK FOR BEGINNERS IN RESEARCH WORK, by Nellie Thompson Landblom. *Emeritus, Assistant Professor of Mathematics and Research Statistician, Colorado Agricultural and Mechanical College, Fort Collins, Colorado.* Paper. 123 pages. 21×27.5 cm. 1955. Multigraph Service Bureau, Colorado A & M College, Fort Collins, Colo. Price $2.95.

ARITHMETIC IN THE ELEMENTARY SCHOOLS. A CURRICULUM GUIDE PREPARED BY THE DIVISION OF ELEMENTARY EDUCATION. Paper. Pages xii+148. 20×28 cm. Bureau of Publications, Baltimore Public Schools, Baltimore 18, Md.

STATE POLICIES AND REGULATIONS AFFECTING THE JUNIOR HIGH SCHOOL, by Grace S. Wright. Bulletin 1955, No. 12. Pages vi+32. 15×23 cm. Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C. Price 20 cents.

ON THE TEACHING OF ELECTRICITY IN SCHOOLS, by R. A. R. Tricker., M.A., Ph.D. Paper. 48 pages. 15×22.5 cm. 1955. John Murry, Publishers Ltd., 50 Albemarle Street, London. W. 1.

THE STUDY OF PLANT ANATOMY, by Dr. D. J. B. White, *Department of Botany, University College, London.* Paper. 11 pages. 15×22.5 cm. 1955. John Murry, Publishers Ltd., 50 Ablemarle Street, London. W. 1.

EDUCATION DIRECTORY, 1954–55. Part 4, Education Associations. Paper. 56 pages. 15×23 cm. Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C. Price 25 cents.

BOOK REVIEWS

THE REPUBLIC OF INDONESIA, by Dorothy Woodman. Cloth. Pages ix+444. 13.5×21.5 cm. 1955. Philosophical Library, Inc., 15 East 40th Street, New York 16, N. Y. Price $6.00.

This is a book needed by everyone because it is about our newest republic. We have known of the land of spices from far back in the history of Mediaeval times but to most of us that land was just some vague place between the Indian Ocean and the broad Pacific. It was not until General McArthur had slipped out of Manila, down underneath to Australia, and then started his island hopping trip back that we began really to look on our maps for the strange names of strange places reported by our newsmen of the location of our fighting forces. Since that time we have learned a little of the rule of the Dutch as they mastered climate, tropical wildernesses, hitherto unknown diseases, and forced into slavery the natives with strange manners and customs, various religions and beliefs, crude types of dress or none at all, while they gathered in the bountiful products and wealth of the distant islands. Then along came the Japs, who killed or imprisoned the Dutch, carried off everything they could lay hands on that was of use in a world at war. Finally came the British and American armies but only the British stayed while the Americans moved on into the Phillipines and then to Japan and Korea. The British served for a short time then invited the Dutch back to take over. By this time many of the Indonesians had learned much and soon took matters into their own hands and became an independent nation, the Republic of Indonesia. From the vast stretch of Sumatra, through the teeming millions of Java, on to Kalimantan (Borneo) Sulawesi (Celebes), the Moluccas to unknown West Irian, over 3,000 miles from Kutaradja where we started, and finally back to Bali, the author takes us and gives a better view of past and present than we have ever had before. It is a book of history and science, geography and products, beliefs and religions. It is a storehouse of knowledge, but gives only a little of all we want to know. But who can tell more in 450 pages, of a vast community of different people whose numbers are now known to be double the estimated number at the beginning of World War II, who people a great series of islands, large and small, and extend over a stretch of the earth's surface that reaches as far as from Maine to California. Read this book as a start, then continue reading all you can find for years to come. You will then still have much to learn about this new republic.

G.W.W.

A TREATISE ON ELECTRICITY AND MAGNETISM, Unabridged, Third Edition, by James Clark Maxwell. Two Volumes Bound as One. Volume I, xxxii+506+13 pages, 39 figures, 13 full-page plates. Volume II, xxiv+500+7 pages, 68 figures, 7 full-page plates. 13.5×20.5 cm. 1954. Dover Publications, Inc., 1780 Broadway, New York 19, N. Y. Price $4.95.

Maxwell's original two volume set came out in 1873, almost a century ago. Later he started a revision which was completed by W. D. Niven in 1881, after Maxwell's death. A second revision by J. J. Thomson came out in 1891. Many books now give extracts of the theory and of the thousands of applications based upon it without any reference whatever to the original author. Some of the authors of these books scarcely know the original source of the material they have presented. But everyone who works in the field of electricity owes a great debt to Maxwell. He is without a peer. The revision by Thomson completed many of the changes started by Maxwell in the first revision and probably add much more than would have been made by Maxwell seven years after the first edition came out. But now the revision by Thomson can be found only in some of the university and scientific libraries. This new single volume gives the exact copy of the Thomson revision at a price everyone can afford to pay. No attempt will be made here to review this printing, but we are glad to point out to both teachers and students that this is an opportunity to become thoroughly acquainted with the thought of the greatest of our electrical scientists.

G.W.W.

PRACTICAL MATHEMATICS REFRESHER, by William D. Reeve, *Professor Emeritus of Mathematics, Teachers College, Columbia University*, and Clarence E. Tuites,

Chairman, Mathematics Committee, and Counselor, Electrical Department, Rochester Institute of Technology. Paper. Pages viii+376. 15.5×23 cm. 1955. McGraw-Hill Book Company, Inc., 330 West 42nd Street, New York 36, N. Y. Price $3.25.

Mathematicians, physicists, chemists, and many teachers in other departments have long complained about the mathematical deficiencies of their students. They seem to have missed entirely some of the important processes found in their work, extending from the elementary school clear on through the junior college. Professors Reeve and Tuites have put up this book to help such students overcome their difficulties. It is a combination textbook and workbook, with perforated pages of exercises and problems that may be removed for grading. Answers are given for the odd-numbered problems. The book may be used either by individual students for self repair of deficiencies or as a classroom text. In many cases much of the theory is not given, or is passed over so lightly that it will prove inadequate for many who may want to know the reason. Teachers may find it necessary to supply the missing proofs and explanations. Examples of this are in the discussion of division by a common fraction, and in changing temperature readings from centigrade to Fahrenheit or vice versa. Some errors are found as in the wording of the rule for pointing off in division of decimals on page 29, and on page 49 the statement is made that "1 cu m of water weighs 1 ton" without any qualification of the meaning of the word "ton." But the authors have selected most of the important difficulties that have plagued students and teachers in later science and mathematics courses, and have provided excellent reviews through trigonometry. It should be used by many to clear up unfamiliar processes encountered in the work of more advanced courses.

G.W.W.

THE COMMON SENSE OF THE EXACT SCIENCES, by William Kingdon Clifford. Paper. Pages lxvi+249. 12.5×20.5 cm. Dover Publications, Inc., 1780 Broadway, New York, 19, N. Y. Price $1.60.

This is not only a reprint of one of the classics which first appeared in 1885, six years after the death of the author, but it contains a long introduction which gives much about the life and thought of the author. This was written by James R. Newman. A very interesting Preface by Bertrand Russell is dated 1945. Many parts of the book were revised by Karl Pearson, who took over the work after the death of Professor R. C. Rowe, the man who was first selected to complete the book. This final form is thus the work of three men, but the revision in no way indicates the work of the two except in some of the footnotes. Both physicists and mathematicians will find it very interesting. The title as first planned by Clifford was to have been, *The First Principles of the Mathematical Sciences Explained to the Non-Mathematical*, and was to have contained a sixth chapter on *Mass*. A short time before his death Clifford requested that the book be revised before publication and that it be entitled, *The Common Sense of the Exact Sciences*. It finally appeared in its present form covering the five chapters: Number, Space, Quantity, Position, and Motion. A Bibliography of Clifford's major writings is appended.

G.W.W.

MATHEMATICS FILMSTRIPS

MAN AND MEASURES, new set of 4 color filmstrips on mathematics (with captions), set $20, or $6 each. Produced and distributed by The Filmstrip House, 15 West 46th Street, New York 36, N.Y.

"This set dramatizes the historical background of mathematics in terms that have real life meaning to children and young people. Geared to the junior and senior high school mathematics curriculum, the strips were written and illustrated by Miss Agnes Herbert, a practising mathematics teacher in Baltimore, and edited by Reid Irving. . . . Titles of the four strips are: *Early Counting, EarlyMeasuring, Early Time Telling*, and *Geometric Figures*."

The reviewer has gone over these filmstrips carefully and believes that they will be found to be exceedingly helpful and interesting. No one should expect that any small number of pictures can give a complete view of the topic under discussion, but these strips will put "real life meaning" into the subject that has been found so frequently to be lifeless and non-interesting to many high school and junior high pupils.

Early Counting starts with the ancient caveman painting lines and pictures on the rock walls of his cave home. Then it shows the progress made by use of the fingers, and later by the Arabic (pointing out that this system originated with the Hindu people) system of counting, and compares this with the cumbersome method of the Romans. The 36 views given here may well be worth the price to *each* student in the class. The few words given with each picture will form the basis for discussion and elaboration in each group of students. The other three films are fully as interesting and valuable. There is nothing in the producer's letter given above that overemphasizes the facts. Some minor omissions in the films were noted: In *Geometric Figures* the discussion and views given all are of the *right* prism, no mention being made of the oblique prism; in the view of quadrilaterals the trapezium is completely neglected. Such eliminations may be easily pointed out by the instructor, either by questions or by the general discussion which should accompany each showing.

G.W.W.

ARITHMETIC WE NEED, Grades 3, 4, 5, 6, and 7, by Guy T. Busswell, *University of California, Berkeley;* William A. Brownell, *University of California, Berkeley;* and Irene Sauble, *Detroit Public Schools, Detroit, Michigan.* Cloth. 15×22 cm. Grade 3, 148 pages. Grade 4, 136 pages. Grade 5, 136 pages. Grade 6, 136 pages. Grade 7, 136 pages. 1955. Ginn and Company, Statler Building, Boston 17, Mass. Price each $2.08.

TEACHING ARITHMETIC WE NEED, by the same authors. Paper. 17.5×23 cm. Grade 3, 354 pages. Grade 4, 357 pages. Price, each $1.60.

This set of books presents arithmetic in a manner that would have startled both teachers and pupils a generation ago. They are well illustrated in many colors, explain each new mathematical idea completely, and give an abundance of practice exercises. Important items that need particular attention are set in colored type. Each new idea is repeated again and again in new forms until the slowest of normal minds can grasp it.

The two manuals for teachers are something really new. The authors recognize that teachers have trouble in putting out the material of instruction. Provision is fully made for overcoming the difficulty. Do not try to teach until you have looked over these manuals. You will use them daily. We congratulate both authors and publisher on the presentation of this new set of books.

G.W.W.

TEACHING SCIENCE TO CHILDREN, by Julian Greenlee, Ed.D. *Professor of Elementary Science Education, Florida State University, Tallahassee, Florida.* Paper. Pages x+185. 21×28 cm. 1955. Wm. C. Brown Company, Dubuque, Iowa. Price $3.00.

This is the second edition of a book which came out in 1951. It was "prepared to be used as a source book of science experiences for teachers of young children." This second edition is the result of the success of the first. It contains the desirable features of the first edition but has been rewritten with improvement in both wording and content. Each page consists of a large section of print, which is illustrated by a number of drawings along the margin. These form about a third of each page and were drawn by Robert Henning of Caroline Brevard School, Tallahassee, Florida. In the many schools where a text book of science has not been adopted this book will be of especial interest to the elementary teacher. The

Bibliography gives a list of many of the best publications in the elementary science field, books for teachers, nature study books, leading journals, publishers, and equipment companies.

G.W.W.

ANALYTIC GEOMETRY AND CALCULUS, by Thurman S. Peterson, Ph.D., *Professor of Mathematics, Portland State College, Portland, Oregon.* Cloth. Pages ix+456. 14.5×23.5 cm. 1955. Harper and Brothers, 49 East 33d Street, New York 16, N. Y. Price $5.50.

This text is definitely not a composite or unified book. Essentially, to the author's *Elements of Calculus* he has added 70 pages of material on plane analytic geometry at the first of the book, and 26 pages on solid analytic geometry just preceding material on partial differentiation and multiple integrals. For the teacher wishing a "unified" course, this is not the text; for one wishing a single text covering both analytics and calculus, this by all means should be considered.

The calculus work takes up integration earlier than some books—before considering differentiation of products, quotients, and implicit functions, for example. The applications of integration, restricted to polynomials, are quite extensive; areas, volumes, centroids, moments of inertia, fluid pressure, work—in fact very little is left for new applications of integration.

Some features seem to the reviewer very commendable; for example: the graphs of rectangular and parametric equations are not necessarily the same; a warning about the use of inverse trigonometric functions (p. 169); the advantage of using a constant in integration by parts (p. 258); care needed in using trigonometric identities in evaluating a definite integral (p. 255); alternative selection of constants in integration using partial fractions.

On the other hand, certain features did not meet with unqualified approval: on page 13 it is implied that calculus was a sudden invention, not the culmination of a gradual development; on the next page "rectangular" and "Cartesian" coordinates are considered synonymous; some discussion of the delta-epsilon concept of continuity might have been introduced; not all instructors will agree that $y=x^2-6x-7$ increases for $x \geqq 3$ and decreases for $x<3$ [why the equality sign in one case, not the other?]; on page 95 it would appear that the solution of the problem of finding the rectangle of largest area that can be inscribed in a given ellipse fails to consider a rectangle with sides not parallel to the axes; on page 195 one wonders where in the statement of the problem it is specified that time is measured in seconds as is given in the answer; there is no discussion of symmetry in polar coordinates; problems in improper integrals are worked with a notation which seems not to consider whether the integrand is continuous at the limits of integration; the statement of Rolle's Theorem and the Law of the Mean do not restrict to single valued functions. The fact that the reviewer is using the author's text in calculus indicates that he does not feel these flaws are serious enough to condemn a good text.

CECIL B. READ
University of Wichita

BASIC MATHEMATICS FOR SCIENCE AND ENGINEERING, by The Late Paul G. Andres, *Illinois Institute of Technology;* Hugh J. Miser, *Operations Analyst, United States Air Force;* and Haim Reingold, *Illinois Institute of Technology.* Cloth. Pages vii+846. 14.5×23 cm. 1955. John Wiley and Sons, Inc., 440 Fourth Avenue, New York 16, N. Y. Price $6.75.

The preface states this is a revision and expansion of an earlier book with a slightly different title, the changes including replacing the exercises in the original work. The mere size of the book makes it appear formidable. Although two years of high school mathematics are assumed as background, a considerable portion of the text could be considered review of this material.

The material covers algebra, trigonometry, and plane and solid analytic geometry, rather completely; differential and integral calculus is restricted to

powers of x and the sine and cosine with elementary applications (rate of change, maxima and minima, approximations by differentials, work, area). There is an ample supply of problems with answers to odd numbered exercises.

The reviewer does not like certain features, for example: omission of the restriction that the base must not be zero in laws of exponents [on page 20 $a^0=1$ if $a\neq 0$, but on page 276 $a^0=1$ without restriction]; it is not stated that the graph given by a set of parametric equations may include only a portion of the graph given by the corresponding rectangular coordinate equation; the definition of a mantissa implies that logarithms of integral powers of 10 have no mantissas; the discussion of the solution of a system of three linear equations by determinants seems extremely brief; it might be preferable to say that the slope of a line parallel to the y axis does not exist, rather than that it is infinite [the statements "tan $90°=\infty$" (page 542) and "tan $\pi/2$ is not defined" (page 187) seem to disagree); there is little, if any, discussion of symmetry in polar coordinates. One looks in vain in the index for the concept of a continuous function—perhaps it is not needed. In view of the complexity of other topics treated, it is rather hard to see why the proof of the second derivative test for maxima or minima is beyond the scope of the text.

Some features are unusual, and in general commendable. The treatment of significant digits uses the term "inaccurate digit"—the term "inaccurate significant digit" is surprising and thought-provoking. When the student is asked to work problems or evaluate formulas, he is told what the formula represents—this should make the problem seem of more value than if the information were omitted. There is a nice distinction between the "period" and the "fundamental period" of a function. A chapter on vectors occurs fairly early. It is clearly stated that negative numbers have logarithms even though this is beyond the scope of the text—certainly better than the erroneous statement that there are no logarithms of negative numbers. There is an interesting application of trigonometric identities. The use of the term "j-number" or "j-operator" rather than "imaginary unit" has some merit, although the student will encounter the last term elsewhere. There is some nice work on using complex numbers in electrical circuit analysis. A discussion of the slide rule appears early in the text; there is a brief discussion of logarithmic paper.

If one is not perturbed by the size of the book, it may well be a wise choice for a text.

CECIL B. READ

COLLEGE ALGEBRA AND TRIGONOMETRY, A BASIC INTEGRATED COURSE, by Frederic H. Miller, *Professor of Mathematics, The Cooper Union School of Engineering*. Second Edition. Cloth. Pages xiv+342. 13.5×21.5 cm. 1955. John Wiley and Sons, Inc., 440 Fourth Avenue, New York 16, N. Y. Price $4.50.

Although called "an integrated course," to a large extent one feels this is merely chapters from trigonometry interspersed throughout an algebra text. This is not entirely true, there are attempts at integration, for example the proof that complex roots appear in conjugate pairs employs DeMoivre's theorem; the chapter on solution of rational integral equations ends with a discussion of the solution of transcendental equations; the chapter on inequalities includes a section on trigonometric inequalities. Nevertheless, there is still the feeling that with very little change the material could be separated into two texts.

Certain features pleased the reviewer: statements are almost without exception mathematically correct—the author does not, as is often the case, fail to state carefully the conditions under which a definition or theorem holds. On page 80 there is a very fine illustration of the troubles which may arise if to prove an identity one assumes it true and then deduces a known true relation.

Certain material is included beyond what is often encountered in a text in these subjects; for example, polar coordinates; more extensive work on curve tracing in rectangular coordinates.

Some will object to the omission of any discussion of significant figures, or to the fact that from the definition in the text, the common logarithms of 1, 10, 100, etc., have no mantissas.

Four place tables of common logarithms and of trigonometric functions are included. The supply of exercises is in general adequate, answers are supplied in most cases to all exercises.

CECIL B. READ

GENERAL PHYSICS, by Oswald Blackwood and William Kelley, both of *University of Pittsburgh*. Cloth. Pages i-x+704. 15.5×23.5 cm. 1955. Second Edition. John Wiley and Sons, Inc., New York. Price $6.75.

This is a textbook for general college students, especially for those whose mathematical experience does not extend to calculus. The present revision is an outgrowth of the original edition, which passed through nine printings, and of some 12 years of classroom use. The material has been revised in the light of classroom experience and constructive criticism; changes and additions have been made to incorporate important advances in the field of physics during the last decade.

The field of physics is treated in conventional divisions; Mechanics, Heat, Sound, Electricity and Magnetism, Light, and Nuclear Physics, in sequence. This is done in 49 short chapters. Each chapter ends with a summary, questions or exercises, numerical problems (group A and group B), references. There are five appendices:

A: Numerical Equivalents
B: Mathematical Review (fundamental operations, including trigonometrical functions and logarithms)
C: Electrical Units
D: Supplementary Problems, by chapters
E: Answers to odd-numbered problems in the text.

The authors make skillful use of the student's everyday experiences and interests in the development of topics. Considerable historical background material is woven into the body of the text. The authors' tenet that mathematics should aid, not hinder, the study of physics has been well observed throughout the book. The result is a book that is interesting and easy to read, at the same time not lacking in precision and rigor.

This textbook should serve well the need of college courses in physics and is not beyond the comprehension of better high school physics students.

WALTER G. MARBURGER
Western Michigan College

HANDBOOK FOR TEACHING OF CONSERVATION AND RESOURCE-USE. Prepared by the National Conservation Committee of the National Association of Biology Teachers in conjunction with the American Nature Association under Leadership of Richard L. Weaver, *Conservation Department, School for Natural Resources, University of Michigan, Ann Arbor, Michigan*. Cloth. Pages 499. 15×22.5 cm. 1955. The Interstate Printers and Publishers, Inc., Danville, Ill. Price $4.00.

Here is a book that fills a big need in the conservation education field. It was prepared by the National Conservation Committee of the National Association of Biology Teachers under the leadership of Richard L. Weaver of the University of Michigan Conservation Department.

This handbook is primarily a compilation of conservation education projects and programs being actively carried out in various elementary and secondary schools throughout the country. Teachers engaged in conservation education have contributed information pertaining to their techniques in attacking various problems. These contributions have been organized under the following chapter headings: How Can I Start Teaching Conservation and Resource-Use?; How and Where Can I Get Help to Teach Conservation and Resource-Use?; What Can

I do in the Classroom to Teach Conservation and Resource-Use?; What Can I Do to Extend Conservation Teaching to Other Parts of the School and to the Community?; How Can I Use the School Grounds in Teaching Conservation and Resource-Use?; How Can I Use the Community in Teaching Conservation and Resource-Use?

Included in the Appendix are sections listing titles and sources of literature, films, film strips, texts, and other conservation education materials.

The task of organizing such a great variety of conservation education experiences must have been a difficult job. The experiences run the gamut of the many types of resources involved in the conservation movement. A cursory examination of the handbook leads one to believe that here is such a conglomeration of material that confusion can be the only result. The committee has attempted to bring order out of seeming chaos by beginning each chapter with an outline of the chapter's contents. Insofar as subject matter is concerned, the main headings are the only parts of these outlines of orientation value. The Table of Contents and Index will aid the reader in locating information of a specific nature.

The section of the Appendix entitled, "A Conservation Bibliography," could have been greatly improved if a standard and consistent bibliographical form had been used.

All in all, the National Conservation Committee, Richard L. Weaver, and the many contributors are to be congratulated for bringing together a handbook that will most certainly be welcomed with open arms by individuals concerned with conservation education. This book will be an invaluable guide for teachers and school administrators who are interested in inaugurating a conservation education program. It should be a must for all people engaged in conservation education.

J. HENRY SATHER
Western Illinois State College
Macomb, Ill.

WINGS IN YOUR FUTURE, by Leo Schneider and Maurice U. Ames. Cloth. Pages 14×21 cm. 1955. Harcourt, Brace and Company, 383 Madison Avenue, New York 17, N. Y. Price $2.75.

Two science teachers have produced this interesting little book to give boys and girls a deeper insight into the miracle of flight. It begins simply with an explanation of air, pressure and the basic principles involved with getting a plane into the air and keeping it there. Most of the explanations revolve about simple experiments that demonstrate the major ideas. Jet propulsion is taken up in the same manner with similar experiments that can be performed by most elementary school children. These two chapters are followed by others devoted to the unusual aircraft such as helicopters, convertiplanes, Zeppelins, dirigibles and gliders.

The structure of a typical plane is studied in detail with diagrams and explanations of the functions of each major part. One chapter revolves about a vicarious flight aboard a modern transport, from take off to landing, using typical flight vocabulary and problems that arise in flight. A little space is devoted to flight in the future in terms of jets, rockets and space platforms. The most informative chapter takes the reader behind the scenes at the airport. Here a close-up view of overhauling, preflight preparations, instruments, control and radar will add background even to the instructor's store of knowledge.

Diagrams are clear, simple and effective. More diagrams and a few photographs would have been a major contribution, however. The most important feature is the large number of simple experiments that can be performed by the young reader or most inexperienced science teacher.

Important terms are italicized although technical terminology is kept to a reasonable minimum. This coupled with short sentences makes reading easy and directions simple to follow in the experiments. Although this small book consists of only six chapters, it is packed full of valuable information on a child's level

and would make a suitable gift or valuable addition to the school's science library.

JOHN D. WOOLEVER
Mumford High School
Detroit, Mich.

LABORATORY EXPLORATIONS IN GENERAL ZOOLOGY, by Karl A. Stiles, Ph.D., *Michigan State Univ.*, Manual, Paper. xi+292. 20.5×27.5 cm. 1955. The Macmillan Company, New York, N. Y. Price $3.75.

This is the third edition of a first year college manual which has additional sections from Protozoa to Chordata. The most extensive section revolves about the frog because of its widespread use in labs everywhere. Although the author assures its adaptability to any text, Hegner and Stiles' *College Zoology* is the text for which is has been primarily designed. The arrangement of the material does not require the instructor's strict adherence to the manual's printed sequence. It has been intentionally designed for convenient hopscotching and should last more than a year with many possible variations and advanced work for superior students.

The manual begins its approximately sixty units with the proper use of the microscope, followed by the study of cells, Protozoa, and two units on The Scientific Method. The latter is well done and should be included in many more publications of this type.

Most of the remaining material follows a simple pattern. Several classes of each phylum are taken with examples commonly found and studied in Zoology courses. The sample specimen is described with its physiology, anatomy and reproduction taken in detail. Various experiments are then outlined with a list of suggested drawings, demonstrations and thought questions terminating the unit.

All units are not entirely dissections or "explorations." One is a key to common orders of insects. Another is devoted to the life history and ecology of insects. A third is based on the adaptation of the Honey Bee. Others revolve about Mitosis, tissues and sense organs.

Instructions for dissection are given when the larger phyla are introduced. The important structures to be studied are in heavier type and aptly described for easy recognition during the dissection. Following the exercises are simple diagrams which vary from line silhouettes to detailed diagrams of entire systems. There is an occasional chart to coordinate and summarize the preceding lab work.

Following completion of the phyla, short units on embryology, heredity, ecology and a general key to the animal phyla terminate the manual. The author has done a superior job in revising his work. Schools that are already committed to a special manual could use this to round out their own, otherwise it could be used as part of their supplementary reading list or to back up a weak text.

JOHN D. WOOLEVER

ANIMAL FORM AND FUNCTION, an introduction to zoology, by W. R. Breneman, *Professor of Zoology, Indiana University*. Cloth. 1954. Pages viii+488. Ginn and Company. Price $6.00.

A broad study of animal types along with a topical approach. The study of zoology is presented in terms of uniformity of animal functions which bring certain groups together and at the same time retains the morphology study of the animal kingdom. There is a study of specialization and functional complexity of the interrelated phyla.

Classification and development of groups is included under separate chapters with emphasis on the structural developments that separate one group from another. Functional complexity is traced through interrelated phyla.

Materials included in most introductory general zoology college text books has been included with a more colorful description, an inclusion of materials to create a greater interest in animal forms and bodily processes. Each chapter devoted to functions and life processes show a degree of uniformity in organization

and making comparisons of animals of different phyla possible.

Terminology is meaningful without excessive use of technical terms. The book is interestingly written and can be understood. Illustrations have been well selected with each structure carefully indentified by labels.

This book can be a useful text or as a ready reference to certain animal forms. functions and developments.

NELSON L. LOWRY

GENERAL CHEMISTRY, by L. E. Steiner and J. A. Campbell, *Professors of Chemistry, Oberlin College*. Cloth. Pages x+675. 15×23.5 cm. 1955. The Macmillan Company, 60 Fifth Avenue, New York 11, N. Y. Price $6.50.

Science is considered organized knowledge. The criterion of that organization is varied. For the first course in college chemistry, since the time of Alexander Smith, chemistry text book authors have very generally followed his pattern. His organization was, perhaps, a bit skewed by a concern to make allowance for a beginner's limitations for learning. Smith seemed to be skeptical of the reliability of a beginner's experience as a basis for such a course.

Steiner and Campbell, however, appeared to consider the need for that concern as outmoded. One might infer that the "atomic age," in their esteem, has so challenged modern youth's attention to physical phenomena that they have a markedly greater back log of experiences, that have chemical significance. And, therefore, the job of the teacher is to get at once at the needed systematization of those experiences into an organized form and so made a science.

The authors, in no sense, minimize the laboratory as a contributor and amplifier of those experiences. For them the "experimental reasons behind our contemporary ideas" are basic in developing critical attitudes in our students and in aiding them toward a reasonable comprehension of chemistry as of today and some skill in evaluating that which may be of tomorrow.

For such an approach the authors use the first five chapters, sixty odd pages, to introduce vocabulary (technical and symbolic), theories (molecular, atomic and electronic) and basic generalizations. Here is provided a sort of frame work by means of which the science of chemistry may find an integrated unity.

In chapter six information is to the fore; subject "The Atmosphere." The next chapter becomes specific as it uses carbon for the exposition of crystal physics. That is followed by some elementary chemistry of carbon compounds. More physics follows in chapters on: gases; kinetic theory; liquids and solids. The periodic classification gives impetus to chapters on: nuclear structure; electronic structure; chemical bonding and chemical reactions. Physics of solutions leads to chemical equilibrium.

At the half way point, page-wise, traditional chemistry seems to appear with such captions as: sulfur family; the halogens, and later, the nitrogen family. Metals are served by: metals from ores, metallurgy; the highly electropositive elements; rare earths; elements in the central region and metals and alloys. Later chapters present: principles of qualitative analysis; oxides with water; electrochemistry and colloids. The last five chapters are given to organic and biochemistry.

The authors consistently use the experimental and student experience as "bases for contemporary ideas." The formulations of those ideas and concepts are thus approached inductively. They choose to establish the pattern, not by fiat, but by practice in knowledge organization in a manner that is the more natural learning process.

Since the authors are both experienced teachers of chemistry, there are, as one would expect, many teacher aids such as numerous thought provoking exercises and problems, many diagrams and tables with legends that prompt attention and thought. An especial feature is the emphasis of atomic and ionic radii as conditioners of the behavior of those entities in chemical transformations and structures.

This reviewer was particularly impressed by the skill they have exhibited in

integrating the newer concepts and findings of the last decade into a modern chemical unity. Too frequently general chemistry text books have tried to get up-to-date by "additions" that remind one of the "lean tos" for dwellings, put on without an architect's approval. Teachers of college chemistry will profit by an inspection of this as another way to "keep up with the new" both for content and manner of its organization.

B. CLIFFORD HENDRICKS
Hastings College
Hastings, Nebraska

LABORATORY EXPERIMENTS IN GENERAL CHEMISTRY, by J. A. Campbell and L. E. Steiner, *Professors of Chemistry, Oberlin College.* Paper. Pages xi+283. 20.5×27.5 cm. 1955. The Macmillan Company, 60 Fifth Avenue, New York 11, N. Y. Price $3.40.

The tradition did not unduly hamper these authors either in choice or method of handling.

In forty three chapters, the last nine of which have to do with analysis, they bring students of general chemistry into a laboratory acquaintance with techniques, the characterizing properties of typical elements and substances and the principles of their transformations. One chapter is given to organic compounds.

The feature that disqualifies this as "just ANOTHER" is the attempt to help the student get more than mere information from the experiments. "Not confirmation of facts already known but a (venture) of discovery" is the preface's promise. They have set up a program that will permit each student to proceed at his own pace. As they propose: the laboratory will be, in a sense, a course but loosely related to lecture and class schedule. And, too, as the student progresses and gains in proficiency he is increasingly expected to device his own plans for the experiments.

Two periodic tables, appendices listing apparatus, reagents and special equipment for individual experiments are provided. Only the first seventeen experiments carry diagrams for apparatus set-up. This is one of the few college chemistry manuals this reviewer has seen that ventures to give conscious attention to the student's pattern of experimenting as well as his acquisition of information. It is an original contribution to the teaching aspect of the laboratory program.

B. CLIFFORD HENDRICKS

SCIENCE FOR YOUR NEEDS, by Maurice U. Ames, *Principal of the Frank D. Whalen Junior High School, New York City;* Arthur O. Baker, *Directing Supervisor of Science, Cleveland Board of Education;* and Joseph F. Leahy, *Herrick Junior High School, Cleveland.* Cloth. Pages xii+354. 15×23.5 cm. 1956. Prentice-Hall, Inc., Englewood Cliffs, N. J. Price $3.48.

This book will serve many purposes. Teachers who are selecting a new text for general science will wish to consider it carefully. Although most suitable for a first course in the seventh or eighth grade, it would also be useful for a slow reading group in the ninth grade. Teachers who use several texts or who are looking for ideas for individual or classroom projects might wish to have a set in the classroom library. Lower grade teachers will find it a convenient reference book for better students and core teachers might find it particularly well adapted for their program.

The text does not follow the usual pattern of separate chapters on air, water, heat, weather and so on. Instead, twenty-three problems are grouped under nine larger topics or "cycles." Six of these have a very personal and practical slant. They are: "Securing Your Food," "Securing Good Health," "Securing a Good Home Environment," "Communicating by Wires," "Transportation of Persons and Materials," and "Getting Your Money's Worth in Clothing."

The first cycle, "A Scientific Approach to Our Universe," uses the customary topics in astronomy to introduce and explain the methods by which scientists obtain and check information. This emphasis on scientific methods is followed

up in every chapter both in the discussion of the topics and in the excellent suggestions for student experiments and investigations under the heading, "Can You Do These?" The end material also includes a useful summary called, "Ideas to Remember," two sets of questions (ten multiple choice and eight essay type) plus a well-chosen list of books for "Further Reading."

The last two cycles, "The Story of Living Things," and "The Surface of the Earth," introduce the pupils to the fields of biology and geology. The word "introduce" is used advisedly. This is not intended as a text for a terminal course nor is there sufficient material for a very rigorous one. The book will be most useful if the references mentioned are available to the students.

The text is well written and enlivened with a great variety of excellent illustrations which range all the way from black-and-white or single-color diagrams to full-color photographs. The double-column format and carefully selected vocabulary make it easy to read but there is no feeling that it is "written down." A simple glossary and index are included. This book is extremely appealing to seventh and eighth grade pupils; in fact, this reviewer had difficulty getting it away from her students long enough to review it.

CATHERINE W. DALE
Lincoln School
Highland, Indiana

SOUND BARRIER—THE STORY OF HIGH-SPEED FLIGHT, Sixth Edition, by Neville Duke and Edward Lanchberry. Cloth. Pages xi+129. 12.5×18.5 cm. 1955. Printed in Great Britain by C. Tinley and Co., Ltd. for Philosophical Library, Inc., 15 East 40th Street, New York 16, N. Y. Price $4.75.

This story of high-speed flight is intended for the general, nontechnical reader, presumably adult. However, both the principles and the vocabulary can be readily understood by an intelligent and interested junior or senior high school student. The book makes a poor first impression because of its mediocre paper and binding, but once started, it is a difficult book to put down.

In part 1, the authors discuss the problems of flight in the transonic and supersonic regions and the exciting early attempts to break through what was thought to be a "sound barrier." About half the book (part 2) is devoted to the special problems involved in designing engines and aircraft for high-speed flight and also in protecting the pilot. Parts 3 and 4 cover the various compromises that must be made between theoretical and practical considerations and the possibilities that are being considered for future aircraft.

This book will probably enjoy a rapid circulation in any high school library.

CATHERINE W. DALE

THE GOLDEN BOOK OF SCIENCE, by Bertha Morris Parker, *formerly of the Laboratory School, University of Chicago*. Paper. 97 pages. 26×32.5 cm. 1956. Simon and Schuster, 630 Fifth Avenue, Rockefeller Center, New York 20, N. Y. Price $3.95.

The Golden Book of Science is another excellent addition to the growing list of "giant" Golden Books for children. It is a fine companion book to *The Golden Book of Astronomy* recently published by Simon and Schuster.

The book consists of 66 short chapters, or stories about almost every conceivable science topic of interest to young readers. It includes information on plants, animals, the human body, earth science, air, water, light, sound, astronomy, and many, many other areas. Each section is written in a style easily read and understood by children in the middle-elementary grades; and at the same time is scientifically accurate and up-to-date. In addition, each section in attractively illustrated with large, colorful pictures.

The only criticism of the book is the fact that, in an attempt to cover the many and varied areas of science, the material is of necessity rather superficial. It might have been better if the author had limited the text to a few major science areas and gone into a little more detail.

However, the book should be an excellent source of supplementary reading material for an elementary-school classroom or library. Or it would be an excellent gift for a child interested in the fascinating field of science.

George Greisen Mallinson
Western Michigan College
Kalamazoo, Michigan

NOTRE DAME SUMMER SCHOOL FOR SCIENCE TEACHERS

The University of Notre Dame is instituting a new Summer School Teachers Training Program designed especially for the Teachers in Secondary Schools. The purpose of the program is to fill the need of the High School Science Teachers who devote their time to several subjects but cannot afford to specialize in each of them. It will also complement the undergraduate training of those who followed a General Science program in College.

Two courses each summer for five years will lead to the degree Master of Science in Physical Science. Courses may be selected from Physics together with Chemistry and/or Mathematics according to the needs and the preparation of the applicant. The Physics courses will be accompanied by a laboratory designed especially to aid the High School Teacher. Seminars will be held on teaching aids, laboratory equipment, demonstration apparatus, texts and laboratory manuals. Various industries and publishers have been invited to take part in the display of teaching aids and equipment.

The program is being added this summer (June 15-July 31) to the Teacher Training Programs in Biology, Chemistry, and Mathematics which have been in progress for the last several years at the University. Information concerning any of these programs may be had from the Dean of the Graduate School, Notre Dame, Indiana.

THE NATIONAL COUNCIL OF TEACHERS OF MATHEMATICS

The National Council of Teachers of Mathematics will hold its thirty-fourth annual meeting in Milwaukee, April 11–14. This meeting is being sponsored by the mathematics teachers of the schools of Wisconsin. Every effort is being made to make the meeting interesting and stimulating to teachers from the primary grades through college. Much time will be given to programs aimed at the improvement of teaching techniques.

Among the outstanding speakers are William Brownell of the University of California; William J. Duren, Jr., of the University of Virginia; Vincent Cushing of Armour Research Foundation, Chicago; and Rudolph E. Langer of the University of Wisconsin.

Teachers may visit elementary and secondary parochial and public schools in the Milwaukee area all day Wednesday and also Thursday morning. Interesting demonstrations and teaching techniques are being planned.

Tours of Milwaukee, beautiful city located on the West shore of Lake Michigan, will be available.

Address any inquiries to Miss Margaret A. Striegl, 2247 North 73rd Street, Wauwatosa 13, Wisconsin, Chairman of Publicity Committee.

Prefab Chimney made of a striated aluminum sheet looks like wire-cut brick. Complete with an extension that resembles a flue tile, the chimneys are available in three sizes: a single housing 18 by 18 inches square, a rectangular housing 18 by 36 inches, and a double housing.

OKLAHOMA AGRICULTURAL AND MECHANICAL COLLEGE A HIGH SCHOOL SCIENCE TEACHERS SUPPLEMENTARY TRAINING PROGRAM

SEPTEMBER 1, 1956 TO MAY 31, 1956

Sponsored and supported by the National Science Foundation. Designed to improve the competence of High School science teachers and those who wish to qualify themselves as science teachers. National in scope. Fifty stipends of $3,000 plus fees and liberal allowances for dependents and travel. The program will feature basic and advanced courses and laboratories in biological science, physics, chemistry, and mathematics with seminars, special lectures and discussions dealing with teaching methods and the applications of science in engineering, industry, and research. It is expected that most participants can qualify for an M.S. degree in Natural Science from the Graduate School. Open to high school teachers of science with three or more years experience and to others who are able to profit by the program and qualify as science teachers. Closing date for applications about March 15, 1956. Forms may be obtained from *Professor James H. Zant, Director, Department of Mathematics, Oklahoma Agricultural and Mechanical College, Stillwater, Oklahoma.*

WORKSHOP FOR COLLEGE PROFESSORS AT MICHIGAN

The University of Michigan will offer its fourth annual *Workshop for College Professors* from June 25 to July 13, 1956. Features include presentations by a special workshop staff, discussions, and projects related to individual members' needs.

The Workshop will be directed by Algo D. Henderson, Professor of Higher Education, assisted by John E. Millholland, Assistant Professor of Psychology, and James M. Davis, Assistant Professor of Education and Director of the International Center, University of Michigan. Other University faculty will be available as resource persons, especially to assist individuals to develop new ideas and fresh materials for their academic courses.

Members of the special staff for the *Workshop* are Benjamin Bloom, University Examiner, University of Chicago; Frank R. Kille, Dean of the College, Carleton College; and Tremaine McDowell, Chairman, Program in American Studies, University of Minnesota. They will discuss such topics as course planning, teaching techniques and evaluation.

The *Workshop* will be followed by an *Institute on College Administration*, July 16 to 20. Additional information may be obtained by writing to the Director, Algo D. Henderson, 2442 U.E.S., University of Michigan, Ann Arbor, Michigan.

NEW EXAMINATIONS ANNOUNCED BY THE U. S. CIVIL SERVICE COMMISSION, WASHINGTON, D. C.

There is an urgent need for Chemists, Mathematicians, Metallurgists, Physicists, and Electronic Scientists in the Washington, D. C., area, the United States Civil Service Commission has announced. Vacancies are in various Federal agencies and pay salaries ranging from $4,345 to $11,610 a year.

To qualify for positions paying $4,345 a year, applicants must have had appropriate education or a combination of education and experience. For the position of Electronic Scientist, appropriate technical or scientific experience alone may be qualifying. For higher-grade positions, professional experience is also required. Graduate study may be substituted for all or part of this experience, depending on the grade of position. No written test is required.

Further information and application forms may be obtained at many post offices throughout the country, or by writing to the U. S. Civil Service Commission, Washington 25, D. C. Applicants should ask for Announcement No. 46(B). Applications will be accepted by the Board of U. S. Civil Service Examiners, National Bureau of Standards, Washington 25, D. C., until further notice.

A RESEARCH PROGRAM TO DISCOVER SUPERIOR SCIENCE STUDENTS

A long-range research program designed to discover at an early stage high school students of superior ability is being launched this year by the Engineering Experiment Station of the University of Wisconsin College of Engineering.

In announcing the project today, Dean Kurt F. Wendt of the College, who is also director of the Experiment Station, emphasized that the program is long-range in scope, and its ultimate success depends on cooperation between the University as a whole and the high schools, plus financial support from the state, from industry, and from foundations.

Dean Wendt said that the program is designed not only to discover high school students of superior ability for engineering and science careers, but also to find young students of superior ability for the liberal arts and all professions.

"The long-range goal of this program is to find, develop, and conserve our most important natural and intellectual resource—gifted young men and women of superior intellectual ability—for national survival," Dean Wendt said.

Immediate objectives of the UW's new search for Wisconsin's "super-students" are:

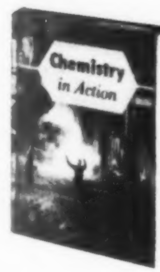
1. To develop methods and procedures for finding superior secondary school students in first year high school with potential ability to become engineers or scientists;
2. To guide and encourage the academic development of all students identified as superior or gifted in order that they can achieve the maximum in a course of study which will give them entrance to any undergraduate college or to any college of a university; and
3. To assist identified superior or gifted students with counsel and financial aid, if needed, until they complete a degree in the college of their choice.

Meeting your teaching needs . . .

Heath science texts

Chemistry in Action, 3rd ed.

RAWLINS and STRUBLE



Published this year. A thoroughly tested text—teachable, logical, adaptable—this book includes the latest developments in chemical research. The functional use of color—for emphasis in the drawings and to mark special sections in the text—is an aid to both student and teacher. *Teacher's Handbook, Laboratory Manual and Key, Tests and Keys*

Semimicro Laboratory Exercises in High School Chemistry, 2nd ed.

F. T. WEISBRUCH

Published this year. Here is a clean, safe, inexpensive, adaptable method of teaching in the laboratory. The Second Edition contains new experiments and illustrations, incorporates improvements in technique, and provides experiments to enable students to work out individual methods at their own speed. *Teacher's Handbook and Guide*

Physics, The Story of Energy, 2nd ed.

BROWN and SCHWACHTGEN

This is an outstanding text based on man's use of energy. Subject matter is presented in order of difficulty—sound, light, mechanics, electricity, motion, and heat—thereby stimulating interest and paving the way for an early mastery of principles. *Teacher's Manual, Laboratory Manual, Comprehensive Tests*

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